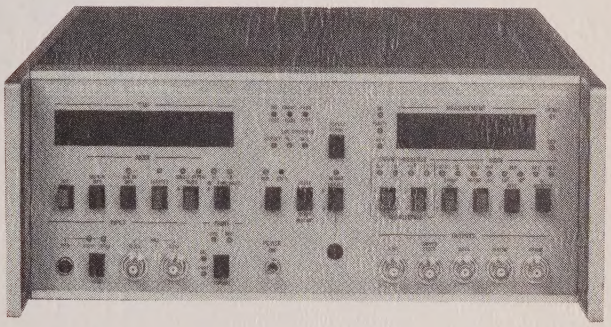
OPERATOR'S MANUAL

03M10C34

Model 4657
DS3 Error Rate Analyzer



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Scientific Atlanta

Model 4657
DS3 Error Rate Analyzer

Operator's Manual

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INSTRUMENTATION

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CHAPTER 1
GENERAL INFORMATION

1.1 GENERAL

This instruction manual contains information for the installation and operation of the Scientific-Atlanta Model 4657 DS3 Error Rate Analyzer. The theory of operation, maintenance, parts listing, and applicable drawings are contained in a separate instruction manual identified for MAINTENANCE.

We recommend before operation, or attempting an adjustment for repair, reading the appropriate sections in this manual carefully. Factory or customer specified modifications, when applicable, and/or general instruction manual updating will be described in a Notice Sheet and will be contained in the rear cover envelope of the appropriate Instruction Manual.

1.2 PURPOSE OF EQUIPMENT

The complete Error Rate Analyzer package consists of two units: (1) the Model 4651A BERTS Transmitter, and (2) the Model 4657 Analyzer. These units are designed to aid testing digital-to-digital measurements on digital transmission equipment such as DS3 (44.736 Mbit/sec) digital data links. The 4651A BERTS Transmitter generates test signals while the Model 4657 Analyzer performs a variety of error measurements on the received data. The Model 4657 Analyzer can also be used to monitor the AGC voltage on digital radios (optional). This allows the correlation of changes in AGC voltage with bit error rate. Normally, the Model 4651A Transmitter would be connected into a DS3 transmitter which transmits digital data over various media (microwave, optical, cable) while the DS3 receiver output would be input into the Model 4657 Analyzer for error measurements.

The Model 4657 Analyzer can be operated remotely over either IEEE-488 bus or RS-232C data links. The 4657 Analyzer can also drive the optional Model 4650 Printer from its power supply to provide permanent records of local data logging. The printed display is that of a 21-column alphanumeric format.

The Model 4657 Error Rate Analyzer, along with its counterpart, the Model 4651A BERTS Transmitter, provides total measurement capability for field use, commissioning, or for laboratory tests.

1.3 GENERAL DESCRIPTION

Normally, the Model 4657 Analyzer recovers the clock signal from the 44.736 Mbit/sec input data and synchronizes on the DS3 framing bits. After synchronization, the analyzer circuits perform bit-by-bit measurements for bit error, parity error, and for bipolar violations. Error rates for bit, parity, and bipolar violations can be measured every 10 million bits or 100 million bits. A real-time clock (with month, day, hours, minutes, and seconds capability) provides timing for error logging. The clock feature can also be operated in an ELAPSED (or count up) mode or preset for a TIMED (or count down) test. While operating in the time modes, error-seconds, total errors, and average bit error rates are measured for all three error types.

When a TIMED or ELAPSED TIME test is running, all measurements are made with respect to the 4 available bit error rate thresholds: 0, 10^{-7}, 10^{-6}, and 10^{-3}. Each Error-Second is classified and its errors are accumulated under the appropriate threshold. This data is then used as a basis for Total Errors, Average Bit Error Rate (BER), Error-Seconds, and % Error-Seconds results, which are available at all 4 thresholds.

The Model 4657 Analyzer has two DC VOLTAGE inputs for measuring the AGC voltage and two DRY CONTACT inputs for monitoring the status of alarms. Thresholds may be programmed for the two DC VOLTAGE inputs so that any excursion above the high or below the low thresholds will cause a front panel indicator to illuminate or trigger a printout on a model 4650 Printer.

Input signals to the Model 4657 Analyzer can be either DS3 bipolar or NRZ unipolar format. The analyzer can also drive an optional local printer (Model 4650) for data logging. For remote operation applications, the analyzer can be operated from either an IEEE-488 bus (Option 257189) or through an RS-232C interface (Option 257190).

1.4 TECHNICAL CHARACTERISTICS

A summary of technical characteristics for the Model 4657 Error Rate Analyzer components is provided in the following specifications:

B3ZS Input (bipolar signal)	
Rate:	44.736 (±0.1) Mbit/S
Impedance:	75 ohms
Return loss:	Greater than 20 dB for a 3 nS rise time pulse
Connector:	Accepts a WECo 440 type
Sensitivity:	Switch selectable (HI/LO and DSX-3) to match the available signal: HI/LO: Operates to 22 dB below DSX level DSX-3: Provides compensation for a DS3 data signal passed through 450 feet of type 728A cable
Pulse Characteristics	
Width:	11.2 (±1.1) nS
Rise/fall:	4.5 (±1.5) nS
Signal Format:	Bipolar B3ZS with or without DS3 framing bits
NRZ Input (unipolar signal)	
INPUT - CLOCK	
Connector:	BNC type
Impedance:	75 ohms, ac coupled
Frequency:	10 to 46 MHz, 1.0 to 2.0 volts peak-to-peak

INPUT - DATA	
Connector:	BNC type
Impedance:	75 ohms, dc coupled, selectable for 10K type ECL, TTL, or 2 volt bipolar centered about 0 volts. Level and data polarity selection is by means of an internal jumper.
Signal format:	Unipolar NRZ with or without DS3 framing structure.
INPUT - External Event Monitor	
Connector:	9 pin D type
DC Voltage:	Two inputs accommodate voltages from -40.00V dc to +40.00V dc.
Dry Contact:	Two inputs sense open-and-short circuit.
Synchronization (any input type)	
Framing:	Automatically accommodates to data patterns with or without the framing structure by searching for a PRBS pattern if unable to detect framing. This search operation is disabled during a test.
Definitions:	
"In Sync":	F-Frame = 15 successive F-bits agree with the predicted pattern M-Frame = 2 successive "010" sequences are found
"Out of Sync":	F-Frame = 3 out of 15 F-bits are incorrect M-Frame = 2 out of 3 "010" sequences are in error
Measurement Modes	
Types of Errors:	Measurements are concurrently made on the three possible error types, any one of which may be selected for display.
Bit Errors:	Detected by comparing the incoming data pattern with the output of an internal PRBS generator (available only with PRBS data pattern)
Parity Errors:	Detected by comparing the incoming parity bits with internally computed parity (available only with framed data)
Bipolar Violations:	Detected by keeping track of the alternate mark inversion sequence in incoming B3ZS data (not available with NRZ)

Error Measurements:	From the acquired data, several measurement values may be computed for display
Bit Error Rate (BER) Per 10^7 Bits:	Counts the number of errors in a sample of 10^7 bits and divides the result by 10^7, updating the display every 0.22 seconds
Bit Error Rate (BER) Per 10^8 Bits:	Counts the number of errors in a sample of 10^8 bits and divides the result by 10^8, updating the display every 2.2 seconds
Error Threshold:	During a timed test, one of 4 selectable error thresholds is used to classify error-seconds data: ALL (0), 10^{-7}, 10^{-6}, and 10^{-3}. To be counted at a given threshold, an error must fall in a one-second interval for which the BER exceeds the selected threshold. The one-second intervals may be synchronized to incoming errors (SYNCHRONOUS ERROR-SECONDS) or be tied to the internal clock (ASYNCHRONOUS ERROR-SECONDS) by means of an internal jumper.
Total Error-Seconds:	Number of seconds during the timed test for which the BER exceeded the selected threshold.
% Error-Seconds:	Error-Seconds expressed as a percentage of seconds in the test.
Total Errors:	Total number of errors which occurred during Error-Seconds for which the BER exceeded the selected threshold since the start of the test.
Average Bit Error Rate (BER):	Total errors exceeding the selected threshold divided by the total number of bits received during a test.
Error Bursts:	Available only with 4650 Printer or one of the remote interfaces (IEEE-488 or RS-232C). An error burst is a group of one or more contiguous "Error Milliseconds". The number of bursts in each of three length catagories is tabulated (1-9, 10-99, and > 100) for the error type selected when entering run mode.

Frame Loss Seconds:	Available only with 4650 printer or one of the remote interfaces (IEEE-488 or RS-232C). When a frame loss is encountered, the loss seconds are counted. The data from these seconds is excluded from all other error measurements except 10^7 BER and 10^8 BER. IF there is frame loss when entering run mode, this feature is disabled.
Signal Loss Seconds:	Available only with 4650 printer or one of the remote interfaces (IEEE-488 or RS-232C). When a signal loss is encountered, the loss seconds are counted. The data from these seconds is excluded from all other error measurements except 10^7 BER and 10^8 BER.
DC Monitor:	Two DC VOLTAGE inputs and two DRY CONTACT inputs can be monitored. The first display position in the MEASUREMENT DISPLAY contains the status of the selected DRY CONTACT input (blank = Inactive, A = Active, and H = has been active during the timed test). The remainder of the display shows DC Voltage for the selected input. If the 4650 printer or one of the remote interfaces is also available, out of threshold seconds for each channel is available along with the error quantities of each type for each channel out of threshold.
Indicators	
PRBS Frame Loss:	On when synchronization between the local PRBS generator and the incoming data pattern is not achieved. (More than 1023 errors in 32767 bits.) Blinks at end of a timed test to indicate loss during the test.
Gating:	On, indicates that a measurement is underway. Blinks to indicate display update.
Signal Loss:	On when input data is lost for more than 22 mS. Blinks at end of a timed test to indicate loss during the test.
Frame Loss:	On when framing is not present in the input signal, or was not present when a timed test began. Blinks at end of a timed test to indicate loss during the test.
Remote:	On when a remote device is controlling the 4657 Analyzer via the IEEE-488 or RS-232C option.

Run/Stop:	Red indicates Stop mode; green indicates Run mode. If, during a timed test (Run mode) a test fault condition is encountered (power loss, signal loss, frame loss, PRBS loss, DC out of threshold, or dry contact alarm), the green Run indicator will flash. When the test ends or is stopped, the respective indicators will flash, with the red Stop indicator flashing to indicate power loss.
IN 1 and IN 2 Out of Threshold:	On when DC VOLTAGE for respective input exceeds programmed upper threshold or is less than programmed lower threshold. Blinks at end of a timed test to indicate out of threshold during the test.
Time Display:	Seven-digit numeric display shows time of day, month/day, elapsed time, time remaining in test, or DC voltage thresholds as indicated by the associated mode indicators. Timekeeping is accomplished by means of a real-time clock circuit which is backed up by a Ni-Cad battery to permit timekeeping in the absence of external power, and recovery upon re-application of power. Voltage thresholds from -40.00 to 40.00 may be entered in the TIME display, for the DC MONITOR function.
Measurement Display:	
Error Rates	1.0000 to 1.0×10^{-50}
Counts (error-seconds and total errors)	0 to 999,999 in decimal notation then 1.000×10^{6} to 9.99×10^{50} in scientific notation.
DC Monitor	Leftmost display position is status of selected DRY CONTACT input (blank = Inactive, A = Active, H = has been active during the test). The rest of the display is DC voltage from -40.00 to 40.00. Input 1 data is displayed only if DC MONITOR IN 1 is selected and input 2 data is displayed only if DC MONITOR IN 2 is selected.
Measurement Ranges	
Bit Errors and Bipolar Violations:	2.0×10^{-3} to 1.0×10^{-50}
Parity Errors:	2.1×10^{-4} (all errors) to 1.0×10^{-50}
Total Errors, Error-Seconds	0 to 9.99×10^{50}
DC Voltage:	-40.00 to +40.00

BLUE Signal display:	The characters "BLUE" in the MEASUREMENT display in the RUN mode and BIT ERROR mode.
General Features	
Power Supply:	Operates from either line voltage of 115/220V ac (±10%), 50 to 60 Hz, or station battery of -22V dc to -60V dc with positive ground.
Power Dissipation:	70 Watts
Weight:	10.9 kilograms (24 pounds)
Dimensions:	33.0 cm W x 38.1 cm D x 13.3 cm H (13 in. W x 15 in. D x 5.25 in. H)
Temperature:	Operating: 0° to +50°C Storage: -20° to +50°C

MODEL 4650 PRINTER (OPTIONAL)

Interface Format:	Parallel input, eight-bit-parallel/character serial, standard ASCII format, 21 characters/line
Modes:	ALL or Partial printout modes selectable on the 4657 Analyzer (displays Error Burst Data in ALL mode). For tests greater than 5 minutes, summary printouts (test ending and force prints) will be ALL format. Conditions which trigger printout selectable on the 4657 Analyzer front panel. Printout may be triggered by (a) Bit Error Rate greater than selected threshold, a frame loss second, or a signal loss second, (b) a DC Voltage input going out of threshold, or (c) any of these conditions. Logs on Error-Second until 10 continuous Error-Seconds are encountered. Logs on PRINT command from front panel of the 4657. Logs at end of test.
Power	Derived from the 4657 Analyzer through interface cable.
Printer Format:	Several typical printouts follow:

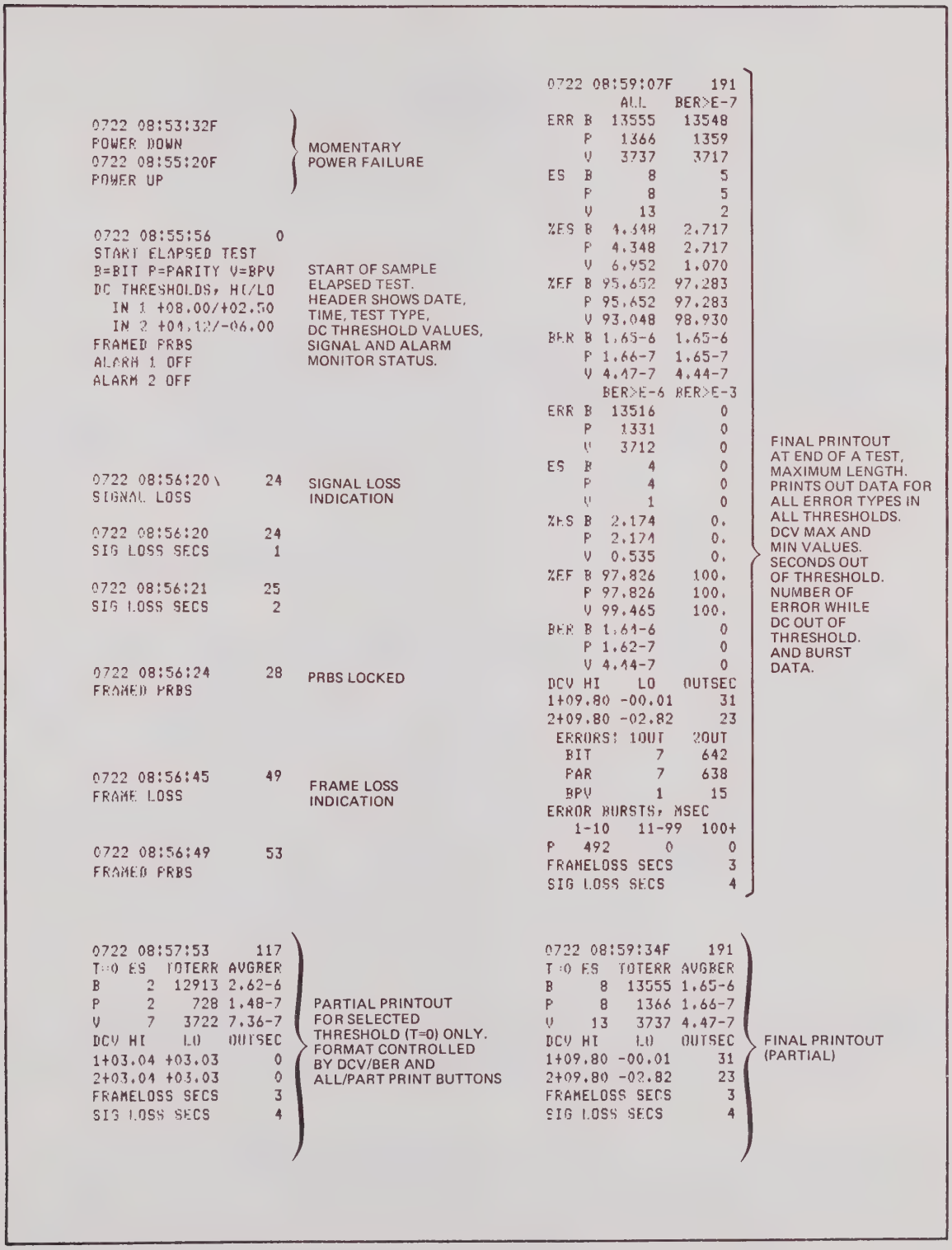


Figure 1.1. Local Data Logging Sample Printout from a Model 4650 Optional Printer

CHAPTER 2
INSTALLATION

2.1 GENERAL

This chapter contains information necessary to properly connect the Model 4657 Error Rate Analyzer into a digital communications system and prepare it for initial operation. Operating instructions are provided in Chapter 3 - OPERATION.

2.2 UNPACKING AND INSPECTION

Carefully unpack the shipping cartons observing all printed instructions. Separate the packing material from the main units and any packages of loose items (i.e., hardware, cables, connectors, etc.). Temporarily set the shipping cartons and packing material aside in a safe place and inspect the units and associated items, if any, for shipping damage. If damage is evident, contact both the carrier and the nearest Scientific-Atlanta sales representative immediately. Save the packing materials and shipping papers for inspection by the carrier's representative. Do not return a unit to Scientific-Atlanta without receiving specific return shipment instructions.

Save the shipping cartons and packing material even after satisfactory operation of the Model 4657 Analyzer is determined. They may then be useful for storage, or for protection during further transport of the equipment.

An inventory checklist is provided in Section 2.3 for accessories that have been supplied with your unit. Should an item be missing (or damaged) from the accessory kit, contact your nearest Scientific-Atlanta representative for assistance.

2.3 ACCESSORIES SUPPLIED

The Model 4657 Analyzer comes complete with the following Accessory Kit (Part No. 256293):

___ Operator's Manual (Part No. 256020)
___ Power Cord (Part No. 89672)
___ Fuses: 10 Amp Slo Blo (Part No. 71236)
___ 5 Amp Slo Blo (Part No. 71232)
___ 2.5 Amp Slo Blo (Part No. 71226)
___ Connector, Rectangular Plug Housing (Part No. 89689)
___ Connector, Contact Pin (Part No. 87460)

In addition, a Model 4657 Analyzer Service Accessory Kit (Part No. 256886) is available. It contains the following items:

1. Maintenance Manual (Part No. 256021)
2. Printed Circuit Board Extender (Part No. 221035)
3. Card Puller (Part No. 254439)

For further information on obtaining a Service Accessory Kit, contact your local Scientific-Atlanta representative, or write/call: Scientific-Atlanta, Instrumentation Factory Service Department, 4388 Shackleford Road, ATL 28-B, Norcross, Georgia 30093, Phone (404) 925-5277.

2.4 INSTALLATION

A. Power Sources

The Model 4657 Analyzer can be operated from either a 115/220V ac 50-60 Hz source or a positive ground battery source providing from -22V to -60V dc.

CAUTION

Be sure the front panel power switch is in the off (down) position before connecting battery source voltage. Although the circuits are voltage protected, it is possible to blow a protecting fuse which is mounted internally and requires partial disassembly to permit replacement.

If there is any question about the power source, it is best to check it with a meter to verify that the voltage is within operating range required by the equipment. It is permissible to connect the unit to both ac and dc power sources simultaneously. The power supply circuit rectifies and filters the stepped down ac voltage which is directed through a diode OR circuit with the applied dc source voltage. Whichever voltage is greater will be the power source for the equipment.

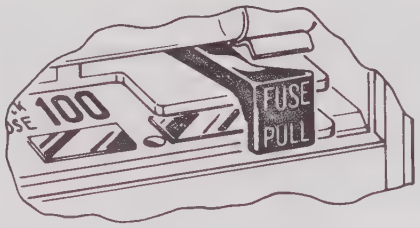
The rectified ac source potential is approximately 55V dc. If the dc source potential is less than 55V dc, the ac source will power the equipment. Likewise, if the dc potential is greater than 55V dc, the dc source will power the equipment. This arrangement permits highly reliable, uninterrupted service modes. Remember that the unit will operate from the higher source potential only, which presents minimum drain on the unused source.

There may be times when a fuse fails and requires replacement. For ac fuse requirements, refer to Figure 2.1 for further instructions. Use only the proper fuse size and rating indicated on the rear panel. DC voltage input fuses are located on a printed circuit board mounted to the inside of the rear panel. Access to these fuses is possible after removing the equipment top and bottom covers.

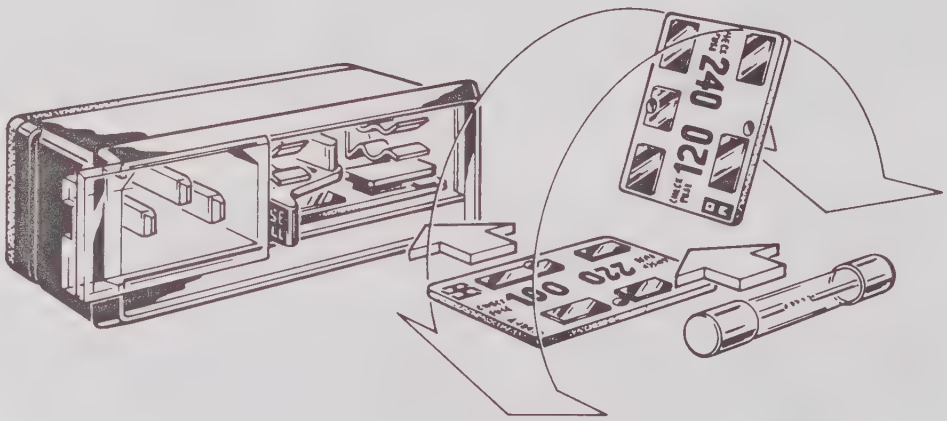
B. Typical Test Configuration

1. Loop-Back Test

Both the Analyzer and Transmitter of a BERTS arrangement are required to perform a Loop-Back Test on a digital radio system, a fiber optics system, or on digital modems. The basic requirements are the same and are illustrated by



Operating voltage is shown through the sliding plastic window.



HOW TO SELECT OPERATING VOLTAGE

1. Remove the ac power cord connector.
2. Slide the plastic window to the left.
3. Carefully operate FUSE PULL tab to the left.
4. Carefully remove both the fuse and printed circuit board. A small hole is provided to accommodate a wire pull if necessary.
5. Correctly orient the printed circuit board so the desired voltage is located on the top left side.
6. Carefully return the printed circuit board to the original location. Be sure it is securely seated.
7. Return FUSE PULL tab to the normal position.
8. Replace the original fuse with one selected for correct fuse value.

Illustrations courtesy of Corcom Corp., Chicago, Ill.

Figure 2.1. Selecting the Proper Operating Voltage

the block diagram in Figure 2.2. The System Under Test transmitter output is conveniently patched to the system receiver. Using similar patching techniques, output signals from a Model 4651A BERTS Transmitter are fed into the system transmitter and a Model 4657 Analyzer is connected into the system receiver output. Test results can verify bit error rate, bipolar coding errors, parity errors, etc. The AGC Voltage of the Digital Radio can be measured and correlated with Bit Error Rate. A permanent copy of test results can be provided through using the Model 4650 Printer Option.

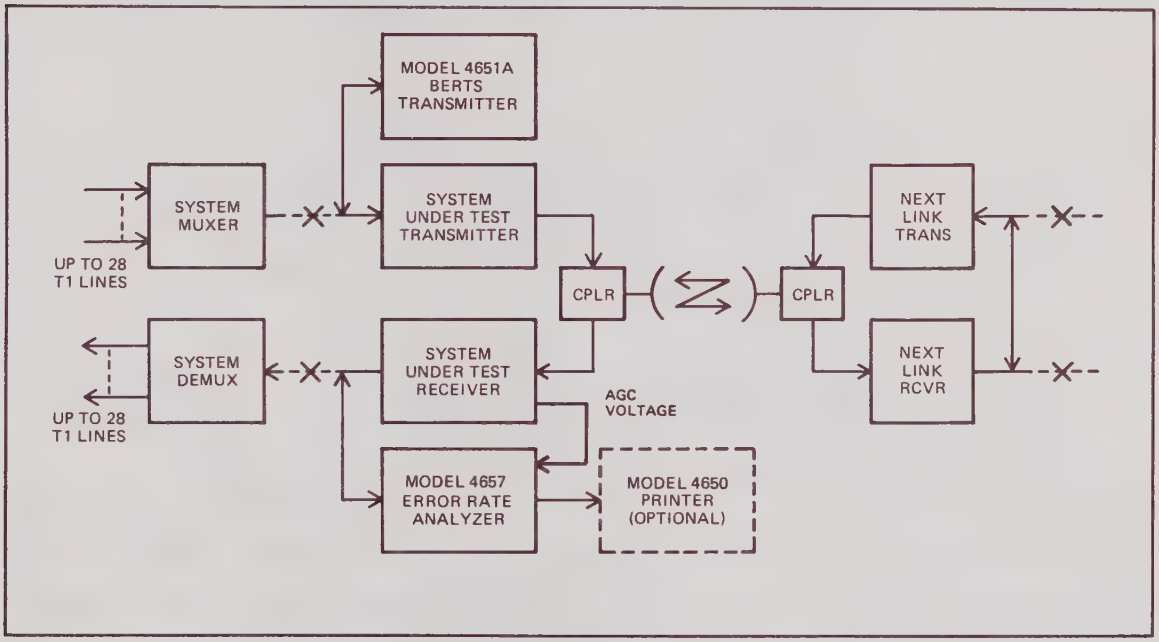


Figure 2.2. System Loop-Back Test Using BERTS Equipment, Block Diagram

2. End-to-End Test

Two individual Model 4651A/4657 arrangements are required to perform simultaneous End-to-End Tests in both directions. A typical set-up is illustrated by the block diagram in Figure 2.3. Patching the respective Model 4651A BERTS Transmitter and Model 4657 Analyzer into the system signal paths, each Model 4657 Analyzer will test evaluate the transmission of the opposite end Model 4651A BERTS Transmitter. Common tests include bit error rate, bipolar coding errors, parity errors, AGC Voltage, etc. The results can be retained on permanent copy when the Model 4650 Printer Option is used.

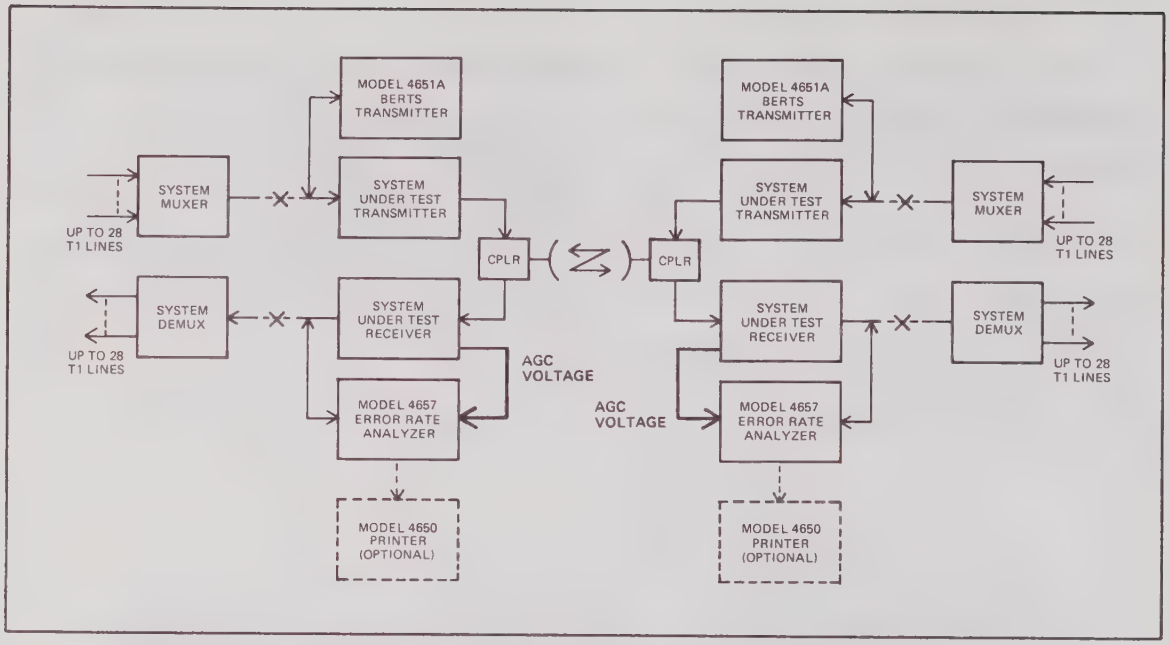


Figure 2.3. System End-to-End Test Using BERTS Equipment, Block Diagram

3. Testing Simulated Fade Conditions

Using the Model 4657 Analyzer (along with a 4651A Transmitter) with a carrier/ noise simulator such as a Scientific-Atlanta Model 4647 IF Noise Test Set (or equivalent), an operator can add noise to the system 70 MHz IF and perform carrier-to-noise versus Error Rate Measurements. This test signal, together with a normal incoming digital signal, simulates noise due to fading. A typical equipment arrangement is shown by the block diagram in Figure 2.4. This method permits Bit Error Rate measurements to be done during production testing of a digital terminal or in the field (commissioning and maintenance) without the scintillation effects of normal RF receive signals.

4. Digital Modem Testing

The Error Rate Analyzer equipment can be used for either production or field testing on digital subsystems which include the modulator/encoder/ scrambler. A typical connection arrangement is shown in the block diagram of Figure 2.5. It should be noted that both bit-error-rate (BER) measurements and clock jitter can be determined using this arrangement of interconnection.

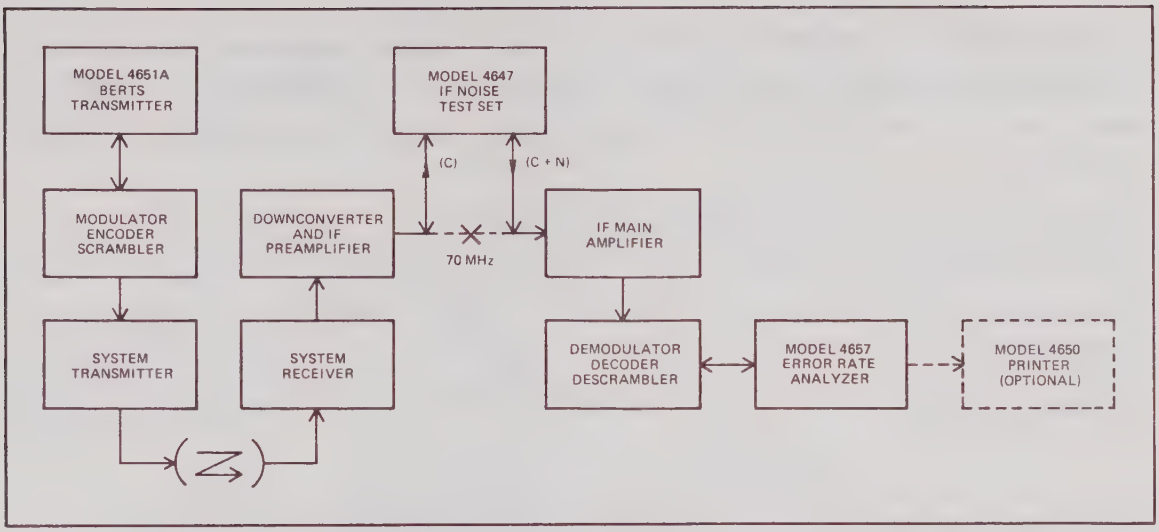


Figure 2.4. Typical Connections for Error Rate Analyzer Equipment When Making Threshold Test, Block Diagram

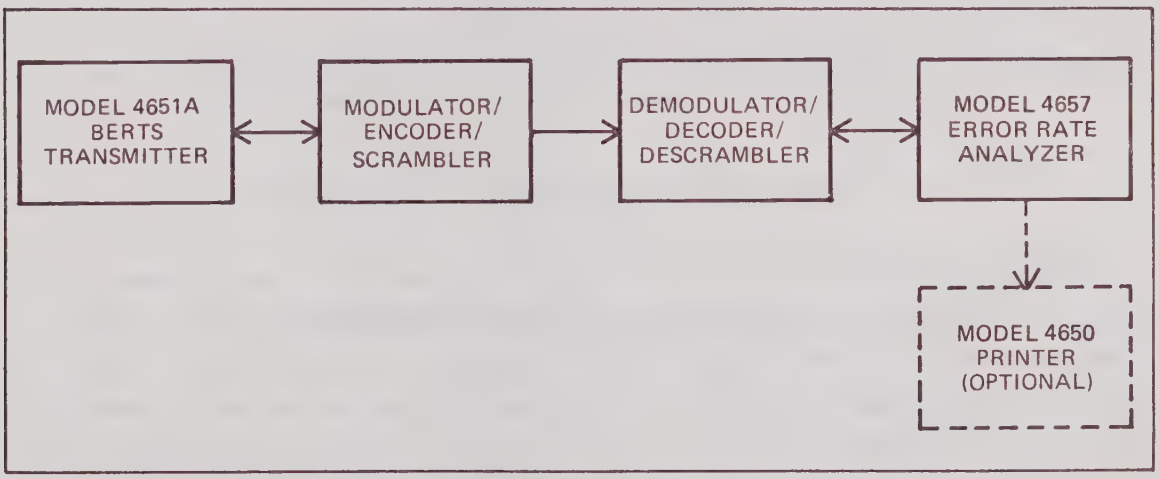


Figure 2.5. Typical Connections for Error Rate Analyzer Equipment When Testing Digital Modems, Block Diagram

5. Digital Modem Testing With Added Noise

The Error Rate Analyzer equipment can be used with a white noise generator, such as the Scientific-Atlanta Model 4647 IF Noise Test Set, or equivalent. Using this arrangement, the operator can adjust the digital subsystem for BER alarm alignment and slicing. A typical connection arrangement is shown by the block diagram in Figure 2.6. In this arrangement, the Model 4647

IF Noise Test Set accepts the carrier signal from the modulators and adds calibrated white noise to the signal for output to the demodulator. The final result is the measurement of bit-error-rate versus Carrier/Noise or Error bits/Noise.

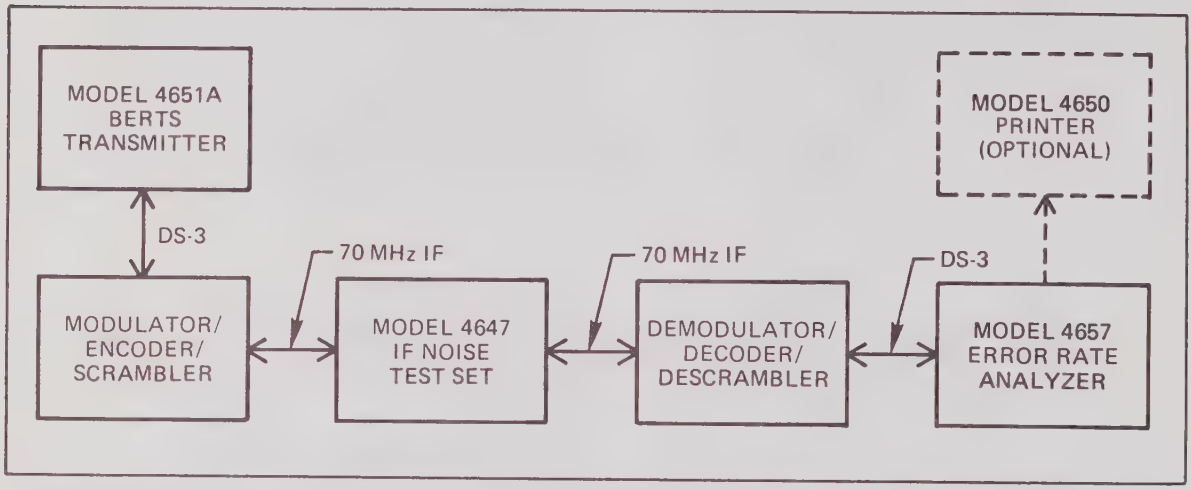


Figure 2.6. Typical Connections for Error Rate Analyzer Equipment When Testing Digital Modems with Added White Noise, Block Diagram

6. In Service Testing of Digital Microwave Radio

Signal continuity can be checked by sampling the framing pulses. If frame lock can be obtained, the signal can be presumed to be operational although the error rate may be high. If frame lock cannot be obtained, the signal is considered nonfunctional. Signal quality can be checked by measuring bit-error-rate (BER), or on-line traffic, parity errors can be measured. AGC Voltage of the Digital Radio can be measured to monitor fading conditions, and the two alarm inputs can be used to monitor radio alarms. These measurements can be made at a station or, with sufficient units, several sections of a microwave link can be sequentially measured or remotely monitored. A suggested interconnection arrangement using the BERTS equipment with an optional remote control interface is shown by the block diagram in Figure 2.7.

In the parity measurement method, the error count is not lost because of regeneration and a test of the parity code will indicate cumulative BER at any point in the system. The DS3 format includes a parity code in the overhead

bit stream. This code may be checked for errors and the error count integrated over time using total errors over total bits in a time mode to provide the total system BER.

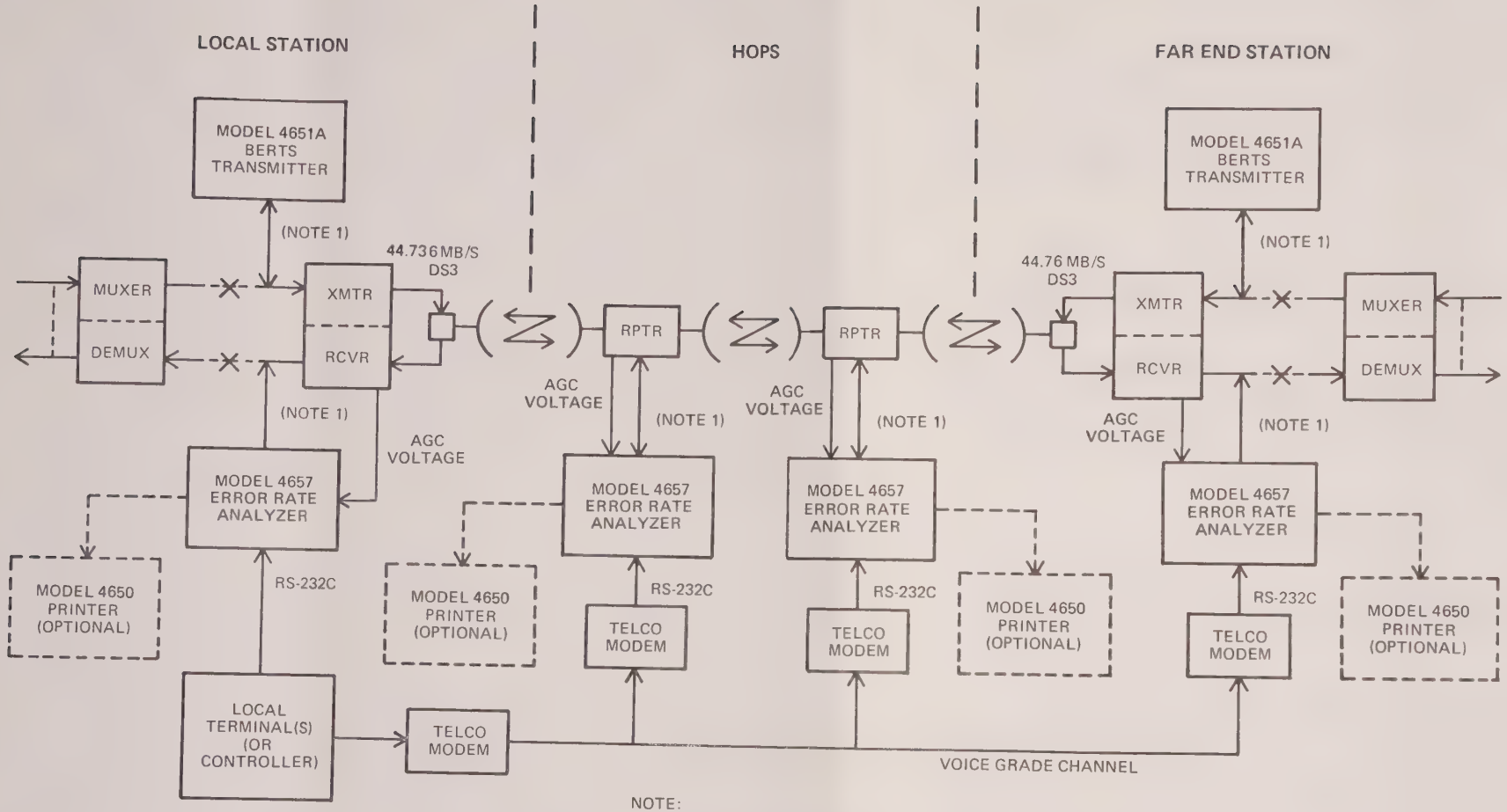
The Model 4657 Analyzer can be used for making measurements on digital transmission with live traffic. When the 4657 Analyzer is provided with back-up dc power input voltage (-22V to -60V), it can be left for long term measurements. Additionally, it can be equipped with an IEEE-488 (Option 257189) or RS-232C (Option 257190) Interface for remote or local control operation.

Using the Model 4657 Analyzer on live traffic, the operator can monitor the following parameters:

a. Parity Errors:Error-Seconds, Total Error, Cumulative BER, % Error-Seconds, BER/10^8 bits, BER/10^7 bits, all at four selectable errors thresholds.
b. Bipolar Violations: Same as listed for Parity Errors.
c. Signal Loss
d. Frame Loss
e. Blue Signal
f. AGC Voltage of the Digital Radio
g. Digital Radio Alarms

7. Testing a DS3 Fiber Optics Communication System

The use of fiber optics is finding wide application in telecommunication, especially in central office to central office transmission schemes. These systems normally use the T3 rate (44.736 Mb/s) which has a 672-voice channel capacity. As in other digital systems, failure in the link is detected using a Bit Error Rate Test Set. The block diagram in Figure 2.8 illustrates typical connections into the Error Rate Analyzer equipment using the DS3 interface point for making these measurements.



NOTE:

1. Use DS3 Input/Output or NRZ (Clock and Data) Input/Output.

Figure 2.7. Typical Connections for Error Rate Analyzer Equipment Used in Service Measurements of Digital DS3 Traffic

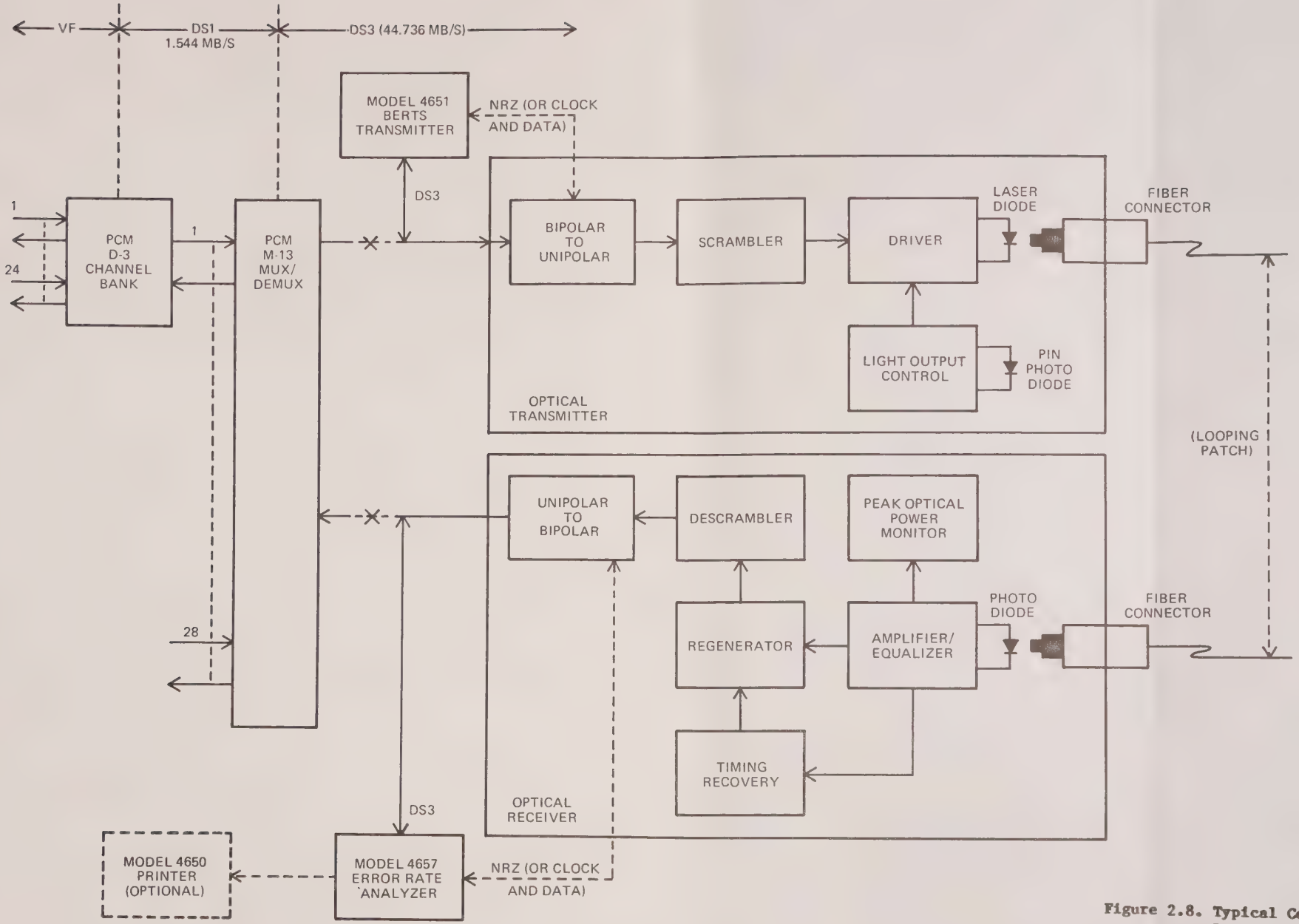


Figure 2.8. Typical Connections Using Error Rate Analyzer Equipment Testing Lightwave Transmission Equipment Operation at T-3 Rate

CHAPTER 3
OPERATION

3.1 GENERAL

This chapter contains instructions for the initial start-up and general operation of the Model 4657 Error Rate Analyzer. It is recommended that operating personnel read this chapter thoroughly prior to using the 4657. While the equipment cannot be damaged by front panel control settings, an understanding of the control functions will reduce the time required to obtain valid measurements.

The 4657 Analyzer provides the circuitry required to: (1) recover the data clock, (2) synchronize on the framing bits, (3) synchronize with pseudo-random data patterns, (4) make bit-by-bit error measurements, (5) select the input signal level, (6) select the error type to be displayed, and (7) provide a real-time clock which can also be used to make timed measurements in three different modes. The 4657 also provides dc monitoring in which two DC Voltages and two DRY CONTACT alarms may be monitored. The Model 4657 Analyzer can also drive an optional Printer (Model 4650) to make a permanent log of measurements. Operation of either the Analyzer or Analyzer/Printer combination can be remotely controlled through optional interface provisions adapted to IEEE-488 (Option 257189) or to RS-232C (Option 257190).

3.2 FRONT PANEL CONTROLS AND INDICATORS

The front panel control switches and indicators of the Model 4657 Analyzer are numerically identified in Figure 3.1. These control switches and indicators should be understood before initiating a test so the results of a test procedure contain the information desired. Functions of the control switches and indicators are listed in Table 3.1.

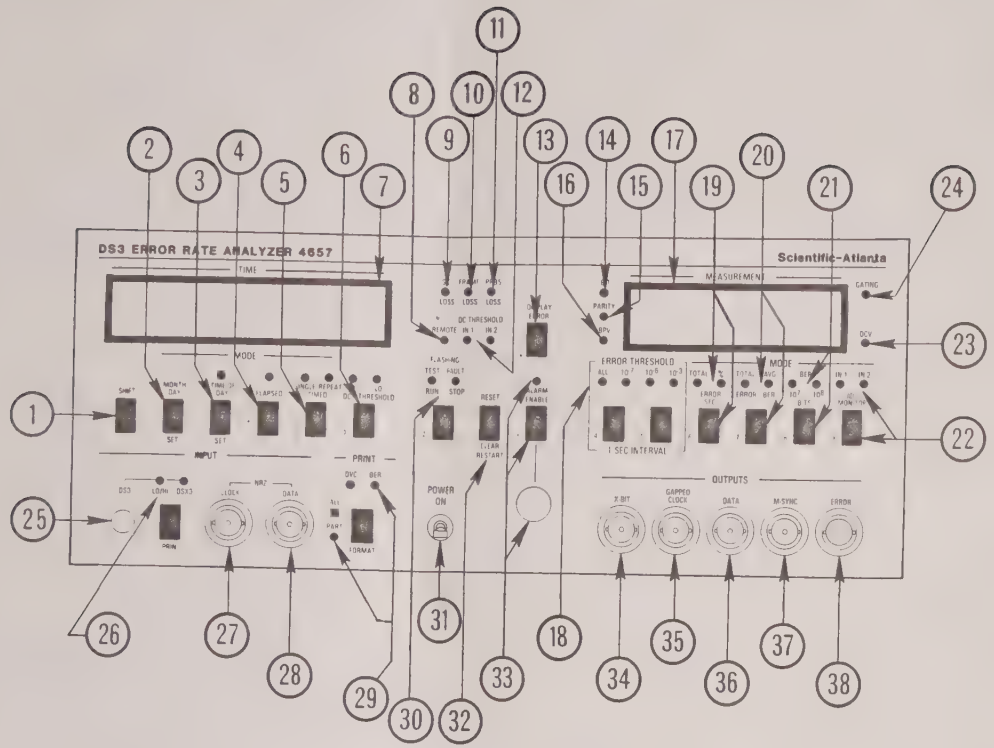


Figure 3.1. Model 4657 Error Rate Analyzer, Front Panel Controls and Indicators

Table 3.1
Model 4657 Error Rate Analyzer
Identification of Controls and Indicators

Reference Symbol	Panel Label	Functional Description
1	SHIFT Switch	This switch operates as a dual function key analogous to a typewriter "shift key". In the normal (out) position, front panel switches operate as the black or the blue labels indicate. When the SHIFT switch is held in, front panel switches with red labels below them are operated into a secondary function. This allows for front panel switches to be used to enter new values into the TIME (7) display as desired.

35R048A

Table 3.1 - continued

Reference Symbol	Panel Label	Functional Description
2	(TIME MODE) MONTH-DAY Switch	Pressing this switch causes the month and day numbers to temporarily appear in the TIME (7) display. If the SHIFT (1) switch is held depressed, a new value of month and day can be entered. Final loading of the new value is entered by pressing the MONTH-DAY switch before releasing the SHIFT switch.
3	(TIME MODE) TIME OF DAY Switch and Indicator	Pressing this switch causes the TIME (7) display to continuously present the time of day in 24-hour format from the internal real-time clock. If the SHIFT (1) switch is held depressed while the indicator is illuminated, a new value of hours, minutes, and seconds can be entered. During this set operation, the indicator will flash indicating the SET MODE.* Final loading and synchronizing of the new value is entered by pressing the TIME of DAY switch before releasing the SHIFT (1) switch. The indicator above the switch illuminates to identify the TIME OF DAY function as being presented in the TIME (7) display.
4	(TIME MODE) ELAPSED Switch and Indicator	This switch provides for selection of the ELAPSED Mode of timer operation in which the TIME (7) display counts up from an entered value while the RUN (31) indicator is illuminated. The ELAPSED Mode is used to totalize error-seconds, errors, and average BER. The indicator above the switch illuminates to identify this function as being presented in the TIME display. This indicator flashes while an elapsed time is being set. Pressing this switch while holding in the SHIFT (1) switch changes the sign of the number being entered in the TIME display.

*SET MODE, including all numerals, ±, and decimal point, only work in STOP MODE.

Table 3.1 - continued

Reference Symbol	Panel Label	Functional Description
5	(TIME MODE) SINGLE and REPEAT TIMED Switch and Indicators	Pressing this switch causes the two indicators to toggle between the SINGLE or REPEAT Timed Countdown Modes of timer operation. In the SINGLE mode, the TIME (7) display counts down from an entered value and stops when the count reaches zero. This mode is used to totalize errors for a preset interval. In the REPEAT mode, the timer counts down from an entered value and repeats the countdown operation until the STOP (30) function is selected. The indicators flash while a SINGLE or REPEAT test time is being entered in the TIME (7) display. Pressing this switch while holding in the SHIFT (1) switch causes a ZERO to be entered in the TIME (7) display.
6	HI or LO DC THRESHOLD Switch and Indicators	This switch provides for the selection of HI or LO DC THRESHOLD to be displayed in the TIME (7) display. This switch may be used in conjunction with the DC MONITOR (22) switch to display the high and low thresholds for Input 1 or Input 2.* The HIGH or LOW indicators illuminate to identify the threshold being presented in the TIME display. They flash to indicate that a threshold is being set. Pressing the DC THRESHOLD switch while holding in the SHIFT (1) switch causes a ONE to be entered in the TIME display. * Note that pressing the DC THRESHOLD switch forces the DC MONITOR MEASUREMENT MODE but that pressing the DC MONITOR switch does NOT force the DC THRESHOLD MODE.
7	TIME Display	These seven characters provide indication of MONTH-DAY, TIME OF DAY, the length of an ELAPSED time test, the time remaining for a TIMED test, or the high or low voltage thresholds.

Table 3.1 - continued

Reference Symbol	Panel Label	Functional Description
8	REMOTE Indicator	This indicator illuminates when operational commands are being received through an optional external interface, either IEEE-488 or RS-232C.
9	SIGNAL LOSS Indicator	This indicator illuminates as an alarm when there is no analyzer input signal or the input signal is of insufficient amplitude. It flashes at the end of a timed test to signify that a SIGNAL LOSS condition occurred at some time during the test.
10	FRAME LOSS Indicator	This indicator illuminates as an alarm when the analyzer cannot find the framing pattern in the received input signal. It flashes at the end of a timed test to signify that a FRAME LOSS condition occurred at some time during the test.
11	PRBS LOSS Indicator	This indicator will illuminate as an alarm to signal that the analyzer has not synchronized its internal Pseudo Random Bit Sequence (PRBS) generator to the received data signal. It flashes at the end of a timed test to signify that a PRBS LOSS condition occurred at some time during the test.
12	DC THRESHOLD IN 1 and IN 2 Indicators	These indicators illuminate when their respective DC Input voltages become greater than the preset high threshold or less than the preset low threshold. They flash at the end of a timed test to indicate that an out-of-threshold condition occurred at some time during the test.
13	DISPLAY ERROR Switch	Pressing this switch selects one of the three error display modes (Bit, Parity, or Bipolar Violations) which the MEASUREMENT (17) Display reflects. Pressing this switch while holding in the SHIFT (1) Switch enters a decimal point into the TIME (7) Display.

Table 3.1 - continued

Reference Symbol	Panel Label	Functional Description
14	BIT Indicator	This indicator illuminates when in the BIT Error Display Mode and signifies that BIT Error Test Data is being displayed in the MEASUREMENT (17) Display.
15	PARITY Indicator	This indicator illuminates when in the PARITY Error Display Mode and signifies that PARITY Error Test Data is being displayed in the MEASUREMENT (17) Display.
16	BPV Indicator	This indicator illuminates when in the BIPOLAR VIOLATIONS Display Mode and signifies that BIPOLAR VIOLATION Test Data is being displayed in the MEASUREMENT (17) Display.
17	MEASUREMENT DISPLAY	These six characters display the current value from the selected error or voltage accumulator as determined by the DISPLAY ERROR (13) switch and the MEASUREMENT MODE (19, 20, 21, 22) switches. The display automatically provides fixed or floating point notation with a range of 1.0×10^{-50} to 9.99×10^{50} for errors and -40.00 to +40.00 for voltage.
18	ERROR THRESHOLD Switches and Indicators	These two switches permit selection of one of the four available thresholds for error measurements: ALL, 10^{-7}, 10^{-6}, and 10^{-3}. Each switch toggles selection between the two associated functions. In the SET MODE, when used in conjunction with the SHIFT (1) switch, these switches serve as digits 4 and 5.
19	(MEASUREMENT MODE) TOTAL or % ERROR SEC Switch and Indicators	This switch provides for selection of TOTAL ERROR SECONDS or % ERROR SECONDS to be displayed in the MEASUREMENT (17) Display. The display value is computed from internally accumulated data based on the selected measurement and threshold and applies only to timed test results. The indicators illuminate when their corresponding MEASUREMENT MODE is selected.

Table 3.1 - continued

Reference Symbol	Panel Label	Functional Description
19	(MEASUREMENT MODE) TOTAL or % ERROR SEC (continued)	Pressing this switch while holding in the SHIFT (1) switch causes a SIX to be entered in the TIME (7) Display.
20	(MEASUREMENT MODE) TOTAL ERROR or AVG BER Switch and Indicators	This switch provides for selection of TOTAL ERRORS or AVERAGE BIT ERROR RATE to be displayed in the MEASUREMENT (17) Display. The display value is computed from internally accumulated data based on the selected measurement and threshold and applies only to timed test results. The indicators illuminate when their corresponding MEASUREMENT MODE is selected. Pressing this switch while holding in the SHIFT (1) switch causes a SEVEN to be entered in the TIME (7) Display.
21	(MEASUREMENT MODE) BER 10^7 or 10^8 BITS Switch and Indicators	This switch provides for selection of BIT ERROR RATE per 10^7 or 10^8 bits to be displayed in the MEASUREMENT (17) Display. The display value is computed from internally accumulated data based on the selected measurement and threshold. The indicators illuminate when their corresponding MEASUREMENT MODE is selected. Pressing this switch while holding in the SHIFT (1) switch causes an EIGHT to be entered in the TIME (7) Display.
22	(MEASUREMENT MODE) DC MONITOR IN 1 or IN 2 Switch and Indicators	This switch provides selection of the INPUT 1 or INPUT 2 DC MONITOR voltages and DRY CONTACT STATUS to be displayed in the MEASUREMENT (17) Display. In this MEASUREMENT MODE, the first display position is always reserved for the DRY CONTACT STATUS (blank = Inactive, A = Active, and H = has been active during the timed test) and the remaining positions indicate the input voltage. The two indicators illuminate when their corresponding INPUT is selected. Pressing this switch while holding in the SHIFT (1) switch causes a NINE to be entered in the TIME (17) Display.

Table 3.1 - continued

Reference Symbol	Panel Label	Functional Description
23	DCV Indicator	This indicator illuminates when in the DC MONITOR MEASUREMENT MODE and signifies that the DC Voltage and status for the DC Input selected by the DC MONITOR (22) switch is being displayed in the MEASUREMENT (17) Display.
24	GATING Indicator	This indicator illuminates constantly when an ERROR measurement is in progress and flashes when the MEASUREMENT display is updated. During a SIGNAL LOSS (9) condition and while running a timed test, 100% errors are added into the totals for bit and parity errors.
25	DS3 INPUT Connector	This connector accepts a WECo 440A-type connector and is the input for DS3 BIPOLAR signals. The circuit impedance is 75-ohms and is ac coupled.
26	(INPUT) LO/HI or DSX3 Switch and Indicators	This switch operates with the DS3 analyzer INPUT connector to configure the circuits to accept either a normal DS3 input signal level (either LOW or HIGH) or to accept the DSX-3 input signal level and enable the internal cable compensation network circuitry. Input signal levels applied when the LO/HI Input function is used are preconditioned by an internal AGC amplifier to compensate for signal level differences. The indicators illuminate when their corresponding Input Type is selected. Pressing this switch while holding in the SHIFT (1) switch initiates a printout of test data.
27	(INPUT) NRZ CLOCK Connector	This BNC-type connector accepts an associated clock signal to be used with NRZ data signals applied to the (INPUT) NRZ DATA (28) connector. The circuit impedance is 75 ohms and is ac coupled.

Table 3.1 - continued

Reference Symbol	Panel Label	Functional Description
28	(INPUT) NRZ DATA Connector	This BNC-type connector accepts data input in NRZ format with DS3 framing bits and no B3ZS. The signal input level can be internally selected between TTL, ECL, or ±1 volt levels. The circuit impedance is 75 ohms and is dc coupled.
29	(PRINT) DCV or BER, ALL or PART FORMAT Switch and Indicators	This switch provides for the selection of the error conditions which will trigger a printout of test data. A printout may be triggered by: a) a DC out-of-threshold error condition, b) a Bit Error Rate which exceeds the selected ERROR THRESHOLD (18), a frame loss second, or a signal loss second, or c) any of these error conditions. The DCV and BER indicators alternate between three states accordingly: a) DCV Indicator only ON, b) BER indicator only ON, or c) both indicators ON. Pressing this switch while holding in the SHIFT (1) switch provides for selection of either ALL or PART PRINT FORMAT. The ALL and PART indicators toggle between these two conditions. For tests over five minutes duration, ALL format will automatically be chosen for test ending printouts and force prints.
30	RUN/STOP Switch and Indicators	Pressing this switch alternately selects between the RUN and STOP modes of timer operation. The switch is necessary for the accumulation of timed errors. Indicator lights for run and for stop are positioned above the switch. A flashing RUN indicator means that a test fault condition (SINGLE LOSS, FRAME LOSS, PRBS LOSS, power loss, dry contact alarm, or DC out-of-threshold) has occurred during the timed test. A flashing STOP indicator means that a Power Loss has occurred. Pressing this switch while holding in the SHIFT (1) switch causes a TWO to be entered in the TIME (7) Display.
31	POWER ON Switch	A two-position switch controlling the application of operating source power to the analyzer circuits. The source power may be either ac or dc.

Table 3.1 - continued

Reference Symbol	Panel Label	Functional Description
32	RESET/CLEAR Switch	Pressing this switch resets the flashing error indicators and resets the internal error accumulators. Pressing this switch while holding the SHIFT (1) switch depressed clears the TIME (7) display and causes the SET MODE to be entered. Pressing this switch in STOP mode while a LAMP TEST is in progress results in a "PRISTINE RESET", returning the unit to the state it was in upon its first power-up. Pressing this switch (either shifted or non-shifted) while in the RUN mode resets the timer to its initial value (0 for ELAPSED and preset numbers for REPEAT or SINGLE), resets the status indicators, resets the Error Counters, and restarts the test with the RUN (30) indicator on.
33	ALARM ENABLE Switch and Indicator	This switch serves to enable and disable the audible alarm function. The indicator is lit whenever the alarm is enabled. Once enabled, the alarm sounds whenever an error-second is logged at the selected threshold and error type (BIT, PAR, BPV) or whenever the selected DC input goes out of threshold. (Note that error-seconds are logged only during a timed test.)
34 thru 38	OUTPUT Connectors	These five BNC-type connectors provide auxiliary output signals identified as (23) X-BIT, (24) GAPPED CLOCK, (25) DATA, (26) M-SYNC, and (27) ERROR. All output signals are TTL levels from 50-ohm drivers. The X-BIT signal is one of the framing bits which can be clocked with the M-SYNC clock. The GAPPED CLOCK is internally gapped during framing bits and may be used to clock the DATA signal. The ERROR signal provides one output pulse for each error of the type selected for display.

3.3 REAR PANEL CONNECTORS

Figure 3.2 shows the rear panel of a Model 4657 Analyzer and the locations of five connectors. They provide interface for (1) the ac power source, (2) the dc power source, (3) the Local Printer (Model 4650) connector, (4) the remote control features through either IEEE-488 (Option 257189) or RS-232C (Option 257190), and (5) the External Event Monitor which includes DC voltage and DRY CONTACT alarm inputs. Normally, only one of the two possible power sources would be connected at a time, although no damage will result if ac and dc power sources are simultaneously applied. The optional data Printer is powered and remotely controlled through the rear panel connector. The Printer will operate by local control or by commands through remote control. Remote control is identified as being either IEEE-488 or RS-232C depending on which I/O option is installed.

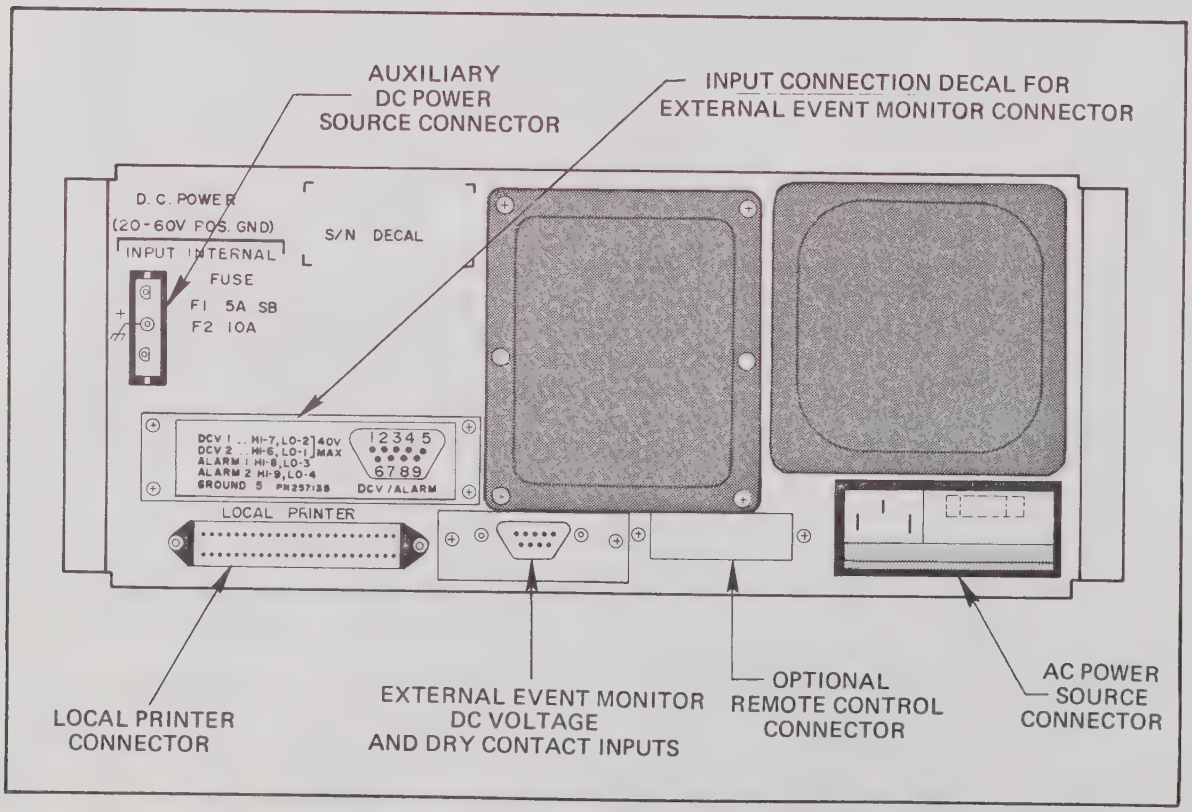


Figure 3.2. A Typical Model 4657 Analyzer, Rear Panel Features

The Model 4657 Analyzer operating under remote control is fully programmable as a talker and listener but cannot be a controller for the IEEE-488 Bus. However, the analyzer may be set up for "talk only" mode operation (for use with an IEEE-488 compatible printer as an example).

3.4 OPERATION - MODEL 4657 ERROR RATE ANALYZER

Although the operation of the Model 4657 Analyzer has been described in figures and tables, there are some operational modes of complex nature that require additional operating instructions. These instructions usually pertain to switches requiring a proper sequence to achieve a desired result or the interaction of various switch combinations.

A. Time Display

Front panel indicators above and between switches are Light Emitting Diodes and, for purpose of brevity, will be referred to as LEDs through the remainder of this section. They should not be confused with the seven segment characters used in the TIME and ERROR displays.

The LEDs over switches below the TIME display indicate by associated switch decal the type of time or voltage data currently being displayed. However, if the RUN LED is illuminated, the MODE LED may not properly indicate in which mode the timed test timer is operating. For example, TIME OF DAY may be selected for the TIME display while an ELAPSED or a TIMED test is running. The TIME display indicates the time of day while the selected timer continues to run. As a second example, ELAPSED time can be displayed if a TIMED countdown test is running but SINGLE TIMED or REPEAT TIMED modes cannot be displayed while an ELAPSED test is in process. If the TIME display indicates either the TIME OF DAY or an ELAPSED time function while the REPEAT mode is enabled,

and when the repeat timer counts to Ø and a new cycle is started, the TIME display is pre-empted to present the new cycle REPEAT countdown. The REPEAT LED is illuminated to alert the operator that one REPEAT cycle is complete.

In the DC THRESHOLD mode, the TIME display is used to display voltages. DC voltages from -40.00 to 40.00 volts may be entered as high or low thresholds for each of two DC VOLTAGE inputs. Two decimal place fixed-point notation is used so that when 12.5 volts is entered, for example, it is changed to 12.50 volts upon exiting the SET MODE (note that the decimal point must be entered explicitly).

1. MONTH-DAY Switch

When the MONTH-DAY switch is pressed, the TIME display indicates the current month and day as determined by the internal real-time clock. The month and day are displayed in the TIME minutes and seconds locations for several seconds and then the display returns to the previous display mode.

2. TIME OF DAY Switch

When the TIME OF DAY switch is pressed, the TIME display indicates the time of day as determined by the internal real-time clock. The TIME display indicates "hours:minutes:seconds" in a 24-hour format. The TIME OF DAY may be selected during an ELAPSED or TIMED test without affecting the measurements.

3. RESETTING CLOCK FUNCTIONS

The front panel SHIFT switch performs a function analogous to the shift key on a typewriter. Normally, the switches respond with the functions marked above them. While the SHIFT switch is pressed, the switches respond to the function marked below them in red.

Note that a flashing LED indicates the SET MODE, that values can only be changed from the STOP Mode, and that, except for the MONTH-DAY mode, only the value corresponding to the illuminated LED can be changed. An invalid set or sequence causes an exit from the SET MODE with the following exception: the attempt to enter a negative value for MONTH-DAY initiates a SELF TEST routine. Resetting values in the TIME display consists of the following four basic steps:

(1) Press appropriate switch to illuminate LED of TIME MODE or DC THRESHOLD to be set. Note that this step is not necessary for setting MONTH-DAY.
(2) Press and hold SHIFT switch.
(3) Enter desired numbers (± or . too if appropriate). Note that LED flashes (except for MONTH-DAY).
(4) If setting MONTH-DAY or TIME OF DAY, then press the desired switch to lock in the numbers and then release the SHIFT switch. Note that the TIME-OF-DAY LED stops flashing if TIME-OF-DAY was entered.
(4A) If setting ELAPSED, SINGLE or REPEAT TIMED, or DC THRESHOLD, then release the SHIFT switch and then press the switch under the flashing LED to lock in the numbers. Note that the LED stops flashing.

a. Resetting Time of Day

Perform the following sequence:

(1) Press TIME OF DAY switch.
(2) Press and hold SHIFT switch.
(3) Enter desired numbers in 24-hour clock format [i.e., 14 (hours) 35 (minutes) 13 (seconds)].
(4) To load and start the clock, press TIME OF DAY switch.
(5) Release SHIFT switch.

b. Resetting Month-Day

Perform the following sequence:

(1) Press and hold SHIFT switch.
(2) Enter desired numbers for month and day.
(3) Press MONTH-DAY switch.
(4) Release SHIFT switch.

Note that the attempt to enter a negative value for MONTH-DAY causes the 4657 Analyzer to enter a SELF TEST mode.

c. Setting Timer Modes

Perform the following sequence:

(1) If necessary, operate RUN/STOP switch to STOP.
(2) Select desired TIMER mode.
(3) Press and hold SHIFT switch.
(4) Enter desired numbers of SINGLE TIMED or REPEAT TIMED test. A 00 is usually used for ELAPSED test. (Note that LED now flashes to indicate SET Mode.)
(5) Release SHIFT switch.
(6) Press timer mode switch corresponding to flashing LED.
(7) Press RUN/STOP switch to RUN to start the timer.

d. Setting DC Threshold

DC Thresholds are entered in the same way as timed test times. Note that the ± and decimal point switches may be used and that only two decimal places are allowed.

e. Invalid Time Entry

An invalid sequence or entry causes an exit from the SET MODE and an error message to appear momentarily in the MEASUREMENT display.

B. Timer Modes

The Timer Modes operate in conjunction with the TOTAL ERROR SECONDS, % ERROR SECONDS, TOTAL ERRORS, and AVERAGE BER switch selected modes since these error measurements require a time reference. For example, 10 ERROR SECONDS has no meaning unless the time period over which the errors occurred is known, such as 10 seconds, 15 minutes, 8 hours, 5 days, etc. Similarly, the TOTAL ERRORS mode must be referenced to a test period. With a known time frame, it can be better understood that the AVERAGE BER mode yields the averaged Bit Error Rate (BER) for the test period. When the RUN/STOP switch is operated to

RUN, all errors, bit parity errors, and bipolar violations of the three error counting modes are all accumulated simultaneously regardless of the error type or error mode selected for display. For example, the error rate ERR RATE/10' BITS may be selected while running a timed test without affecting the error accumulators for the timer measurements. Also, after the test, the ERROR display can be switched between any mode without affecting the error count.

1. ELAPSED Time Test Mode

Normally the ELAPSED time test mode would be started at display TIME of 00 because, in this mode, the timer counts up to 999:59:59 maximum unless the operator stops the test. Pressing the RUN/STOP switch starts and stops the timer. If no previous timed test mode has been selected and the analyzer is initially powered by operating the front panel POWER ON switch, the TIME display illuminates and, after a short pause, acknowledges the analyzer circuits ready by displaying the TIME OF DAY mode. Then if the RUN/STOP switch is operated to RUN, the TIME display automatically resets to :00, the ELAPSED time mode panel indicator illuminates, and the internal timer starts counting up. Otherwise, it will be necessary to CLEAR the ELAPSED timer before pressing the RUN switch. The display can be switched to TIME OF DAY without disturbing the ELAPSED timer. An initial offset can be loaded into the timer before selecting ELAPSED, but this will not pre-load the TOTAL BITS counter to correspond to the entered offset. The TOTAL BITS value corresponds to the length of time the RUN indicator is illuminated.

2. SINGLE TIMED or REPEAT TIMED Test Mode

To initiate a preset internal timed test, first enter the desired time as described in the previous section. Now when the RUN mode is selected, the timer will count down to 0 and stop if the SINGLE TIMED mode has been selected; or the timer will continually repeat until stopped if the REPEAT TIMED mode has been selected. For a 10-second repeat test, the TIME display counts from 9 to 0 rather than from 10 to 1. If a 1-second repeat test is started, the TIME display indicates a continuous 0 since the 0 second is repeated. A

1-second REPEAT TIMED test is convenient to display TOTAL ERRORS on a 1-second update rate.

It is also possible to select between ELAPSED, TIME OF DAY, and MONTH-DAY displays while running a timed test without disturbing the count down timer. During this mode, the ELAPSED command causes the TIME display to indicate the length of time so far completed of the timed test, while the SINGLE TIMED or REPEAT TIMED modes indicate the time to completion of the test. Timer modes can be switched any time between SINGLE and REPEAT without affecting operation of the timer or length of test while operating in the RUN mode. It is only when the TIME display indicates 00 that a determination is made to repeat the cycle, if in the REPEAT TIMED mode. If during a timed test the ELAPSED mode is selected, then whatever mode was previously selected, either SINGLE TIMED or REPEAT TIMED, before the ELAPSED command will determine whether the cycle stops or repeats at 00.

C. Measurement Display

The DISPLAY ERROR switch and the DC MONITOR switch select the error type or voltage to be indicated on the MEASUREMENT display. When the RUN indicator is illuminated, all three error types are simultaneously counted and all DC inputs are continuously sampled. Measurements for each error type are accumulated and stored for all thresholds and are then available for recall and display on command. The DISPLAY ERROR switch in conjunction with the two ERROR THRESHOLD switches, select a desired measurement for display. The DC MONITOR switch selects the desired DC input for display. In this mode, the first display position is always reserved for the DRY CONTACT status (blank = Inactive, A = Active, H = has been active during the timed test) and the remaining positions indicate the input voltage in two decimal place fixed point notation.

Bipolar violations are essentially two successive violations of the same polarity since the first violation is treated as a B3ZS coding substitution and the second as an error. Bit errors are calculated on a bit-by-bit comparison of the pseudo random sequence. Parity errors are determined by comparing

the calculated parity on the data bits with the parity bits contained in the framing bits of the next superframe.

1. RESET and RESTART Functions

When the 4657 Analyzer is in the STOP mode, pressing the RESET switch clears all internal error accumulators at all thresholds. Pressing the RESET switch also clears flashing panel indicators identified as SIGNAL LOSS, FRAME LOSS, DC Threshold IN1 and IN2, and PRBS LOSS in addition to clearing the dry contacts' history indication. (A flashing indicator means that at some point in time when the RUN indicator was illuminated, the identified status was lost and regained. A flashing STOP indicator can only result from a power failure. Otherwise, the respective indicators will be illuminated or extinguished according to the present status.) Pressing the RESET switch will also restart the ERR RATE/10^7 BITS and ERR RATE/10^8 BITS measurement functions.

When the analyzer is in the RUN mode, pressing the RESET switch (either shifted or non-shifted) accomplishes a RESTART of the test as follows: The timer is reset to its initial value, status indicators are reset, the STOP LED illuminates, "START" appears in the MEASUREMENT display, and the test then restarts with the RUN LED on.

2. "PRISTINE RESET" Function

The non-volatile memory in the Model 4657 Analyzer is very convenient in the event of accidental power loss, but to permit simple reset to a known state, a "pristine reset" function is available. This reset is accomplished from the STOP mode by initiating a lamp test provided at power-up and at the end of a SELF TEST, then pressing the RESET button during the lamp test. The lamp test will last longer than usual, as all registers and state variables are re-initialized. The resulting default modes are as follows:

TIME-OF-DAY TIME DISPLAY
STOP MODE
DISPLAY PARITY ERRORS
ERROR THRESHOLD: ALL
10^7 BITS BER DISPLAY

PRINT CONTROL: ALL BER
NON-REMOTE (LOCAL)
LO/HI INPUT MODE
DC HIGH AND LOW THRESHOLDS OF +40.00 VDC AND -40.00 VDC, RESPECTIVELY.

The pristine reset does NOT change the time and date being kept by the real-time clock.

3. MEASUREMENT Display

The MEASUREMENT display provides a read-out range of from 1.0×10^{-50} to 9.99×10^{50} for error data and from -40.00 to +40.00 for DC voltage. The maximum error rate that can be counted for PARITY is 2.10×10^{-4}, or all superframe with parity in error.

If a timed test is running and a SIGNAL LOSS occurs, SIGNAL LOSS SECONDS are accumulated and available on the printer or remote options. During SIGNAL LOSS SECONDS, the test timer continues to operate; however, the seconds are not counted in figuring error-second or % error-second data. In addition, data is not accumulated for TOTAL ERROR or AVG BER measurements. 10^{7} BER and 10^{8} BER continue to function normally. FRAME LOSS is handled in the same fashion.

If the incoming signal contains alternate 1-0 data, this is recognized as an idle channel signal or the "BLUE SIGNAL". The Model 4657 Analyzer will respond to this signal format by displaying "BLUE" in the ERROR display when in the RUN mode and DISPLAY ERROR - BIT LED is illuminated. Both PARITY and BIPOLAR VIOLATION errors can be measured on the "BLUE SIGNAL" and operation in these modes is normal and as previously described.

During the RUN Mode, certain switches are inhibited by the software. For example, Input type may not be changed, numbers may not be entered in the TIME display, etc. When one of these switches is pressed, "IL" (for illegal) will appear in the MEASUREMENT display followed by a two-digit hexadecimal number corresponding to the function requested. Otherwise, the software will ignore the "illegal" switches. Note also that the DISPLAY ERROR switch is always

"illegal" when in the DC MONITOR measurement mode. This will also occur if an illegal command is issued over a remote interface.

D. Measurement Modes

1. Timed Error Counts

The four error measurement modes identified as TOT ERROR SECONDS, % ERROR SECONDS, TOT ERR, and AVG BER, require operation of the timer in either an ELAPSED (count up) mode or a SINGLE or REPEAT TIMED (count down) mode. These functions require a timer reference as a base for the measurement. When the RUN indicator is on, each error-second is categorized as to ERROR THRESHOLD and all errors accumulated. Sufficient data is carried internally to permit display of any of the three error types at any of the four thresholds in any of the four timed test data DISPLAY formats. (The other two DISPLAY modes are applicable only to instantaneous data.) The AVG BER data is the average BER of the entire test.

2. Error Thresholds

The four ERROR THRESHOLDs available, ALL, 10^{-7}, 10^{-6}, and 10^{-3}, represent Bit Error Rate levels which can serve in characterizing link failures. During a test, each second containing errors is categorized as to the threshold. Thus the number of error-seconds, average BER, and derived measurements displayed will vary with the threshold selected, although data is collected at all four thresholds, regardless of the selection.

3. Instantaneous Measurements

Switch selectable measurement rates labeled ERR RATE/10^7 BITS and ERR RATE/10^8 BITS identify the internal analyzer functions. As soon as a measurement is completed, the MEASUREMENT display is updated and a new measurement cycle begins. The rate of 10^7 BITS provides four updates per second. The rate of 10^8 BITS provides one update every 2.2 seconds.

4. Synchronous versus Asynchronous Error-Seconds

An error-second is defined as being a 1-second measurement interval containing errors. However, a given pattern of errors can produce a varying number of error-seconds depending on when the 1-second intervals begin. There are two standard approaches to defining when these 1-second intervals will occur: (1) triggered or "synchronous" error-seconds, and (2) clocked or "asynchronous" error-seconds.

Synchronous error-seconds are measured by defining the 1-second measurement interval as beginning when an error occurs. Subsequent error-seconds begin at the time of the first error following the end of previous error-second. For most patterns of errors, this technique tends to minimize the number of error-seconds.

Asynchronous error-seconds are measured by defining contiguous 1-second measurement intervals for the duration of the test. The first such interval begins as the test begins, and the last ends as the test ends. See Figure 3.3 for a comparison of the two approaches.

Each of these approaches has special characteristics and merits. The main claims for synchronous error-seconds are: (1) minimization of error-seconds for a given pattern of errors, and (2) the same number of error-seconds for a pattern of errors, independent of when the test was started. By contrast, the asynchronous error-seconds technique can have results different from synchronous error-seconds, or even another asynchronous error-seconds test started at a slightly different time. See Figure 3.4.

There are, of course, some disadvantages to the synchronous approach as well. Its complexity can give rise to some startling and unintuitive results. For example, with a BER of 10^{-7} (continuous), synchronous-error seconds will constitute only about 89.5% of the test, compared with 100% if measured by the asynchronous approach. The BER measured <u>during</u> the synchronous error-seconds will average 1.12×10^{-7}, compared with 1.00×10^{-7} if measured by the asynchronous approach. (Note that 89.5% of 1.12×10^{-7} is 1.00×10^{-7}.)

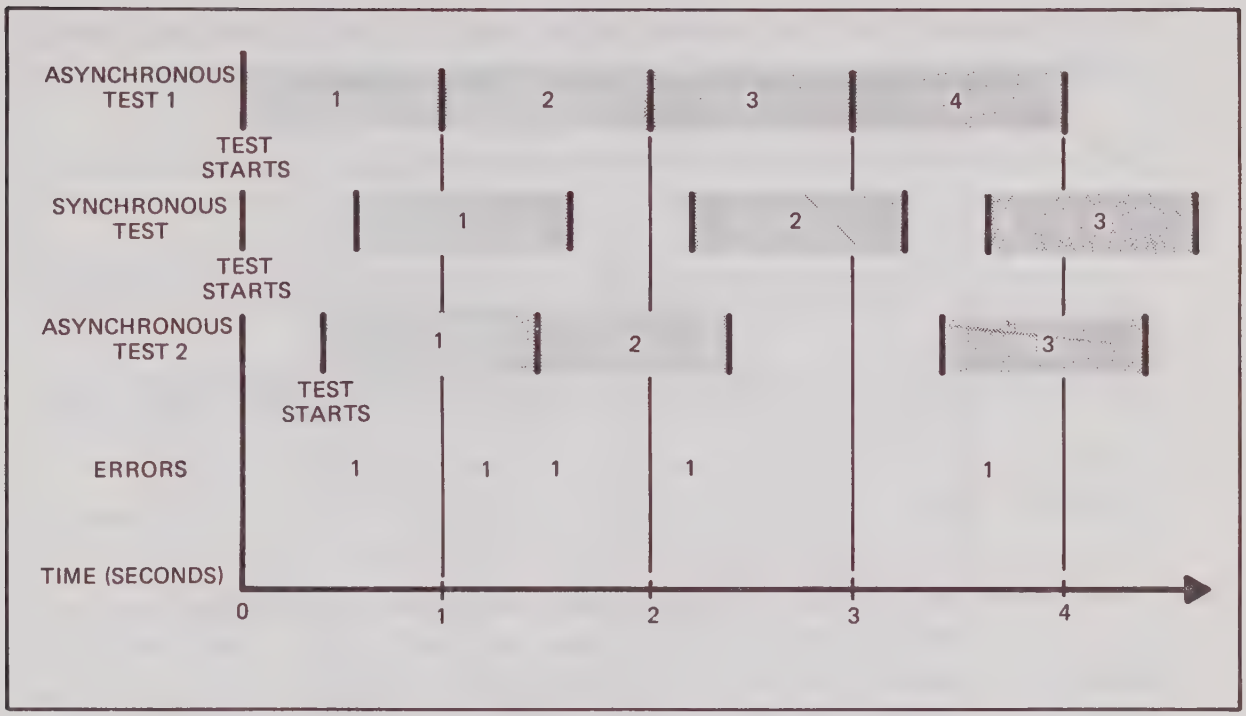


Figure 3.3. Synchronous and Asynchronous Error-Second Comparison

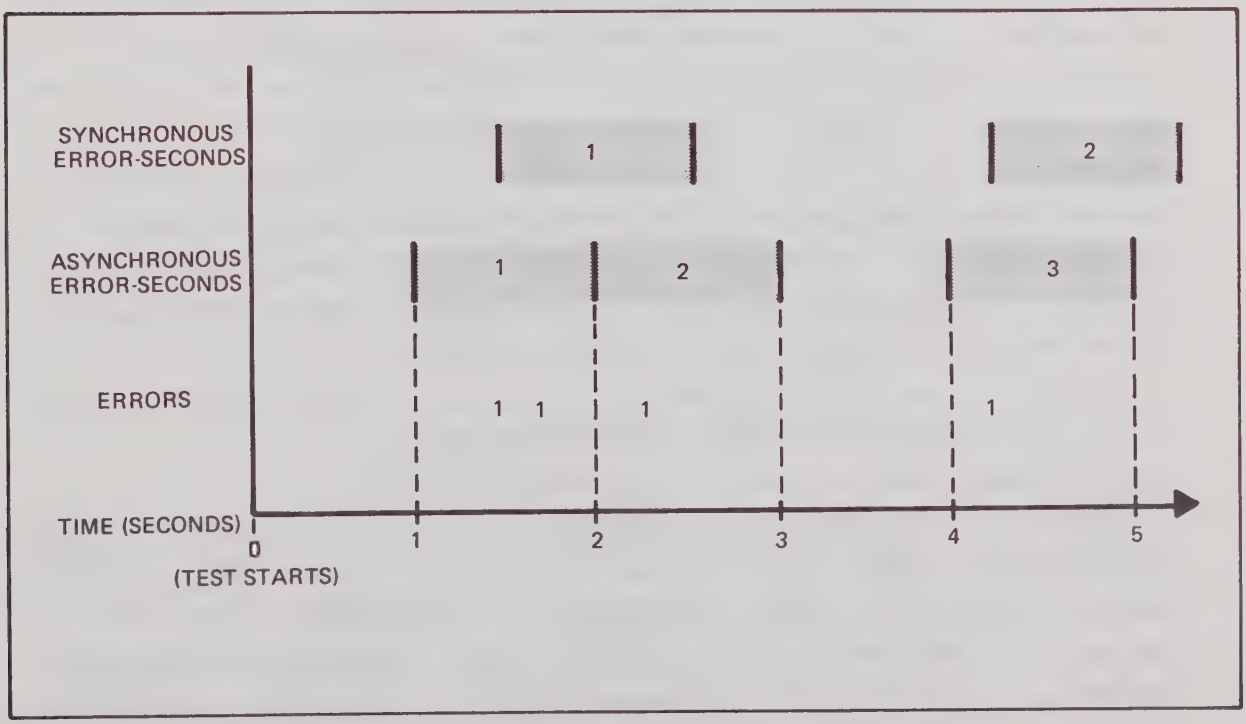


Figure 3.4. Synchronous vs. Asynchronous Error-Second Test Characteristics

Finally, whenever the error logging process happens to catch that 10.5% error-free gap between error-seconds, a BER of 0 will be logged. Refer to Figure 3.5.

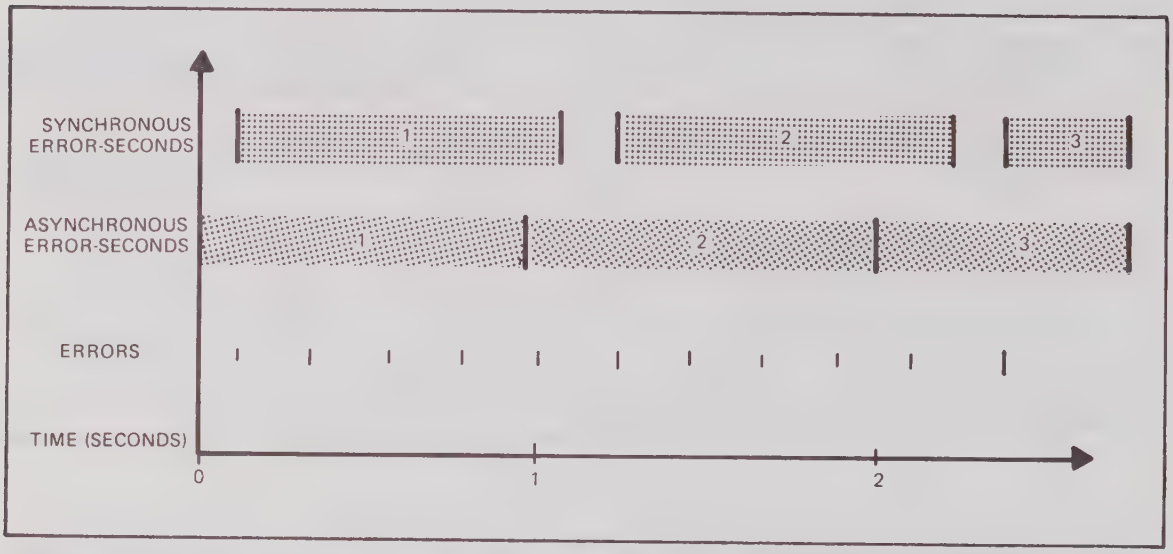


Figure 3.5. Synchronous vs. Asynchronous Error-Second Measurement Results

The most suitable type of error-seconds measurement will depend on the application. The Synchronous/Asynchronous feature also applies to accumulating signal loss and frame loss seconds available on the printer and remote options. A jumper is provided in the Model 4657 Analyzer on the Error Counters 2 & 3 PCB (A7) to allow selection of the measurement approach (see Figure 3.12). When installed, the jumper causes the analyzer to operate in the Synchronous error-seconds mode. On power-up, this jumper is read by the software and either an "A" for Asynchronous or an "S" for Synchronous is put in the fourth display position in the TIME display.

5. External Event Monitor Measurements

The 4657 Error Rate Analyzer accepts two DC VOLTAGE inputs and two DRY CONTACT inputs. These four inputs can be monitored using the DC MONITOR switch. When the IN 1 LED is illuminated, the MEASUREMENT display shows (a) the status of DRY CONTACT INPUT 1 in the leftmost display position (blank = Inactive, A = Active, H = has been active during the timed test) and (b)

the voltage at DC VOLTAGE INPUT 1 in the remainder of the display. When the IN 2 LED is illuminated, data for INPUT 2 is shown in the MEASUREMENT display.

High and low voltage thresholds corresponding to each of the two DC VOLTAGE inputs may be entered using the DC THRESHOLD switch. If an input voltage exceeds its high threshold or becomes less than its low threshold, then the corresponding OUT OF THRESHOLD status LED illuminates.

E. Output Connectors

Five BNC-type OUTPUT connectors provide signals to other peripheral equipment of the user's choice. All OUTPUT signals are TTL levels from 50-ohm drivers. The X-BIT output signal is the X-framing bit and can be clocked into an external device with the M-SYNC signal, which is a superframe clock pulse. The GAPPED CLOCK output signal has gaps during the framing bit intervals and can be used with the DATA output signal for external data loading. The ERROR connector output signal is a pulse having a rising edge for each error of the type selected by the DISPLAY ERROR switch.

F. Input Connectors

1. NRZ CLOCK and DATA

Input data in NRZ (Non-Return to Zero) format having DS3 framing bits can be applied through the NRZ DATA connector directly to the Model 4657 Error Rate Analyzer circuits, bypassing the 44.7 MHz Clock Recovery circuit and the B3ZS Decoders. The NRZ CLOCK connector is a 75-ohm input, ac coupled, for a frequency range between 10 MHz and 45 MHz. The NRZ DATA connector is a 75-ohm input and dc coupled. The data signal input can be jumper selected (internal to the analyzer) for either TTL, 10K ECL, or for ±1.0V Bipolar signals. These jumpers are provided on the B3ZS Decoder printed circuit board (A2). There is also a jumper on this board to select the data signal polarity. (See Figure 3.6.) To access these jumper selections, remove operating power, using the front panel POWER switch. Then remove the top cover of the analyzer and the card retainer ring from the card cage assembly. Printed circuit boards can

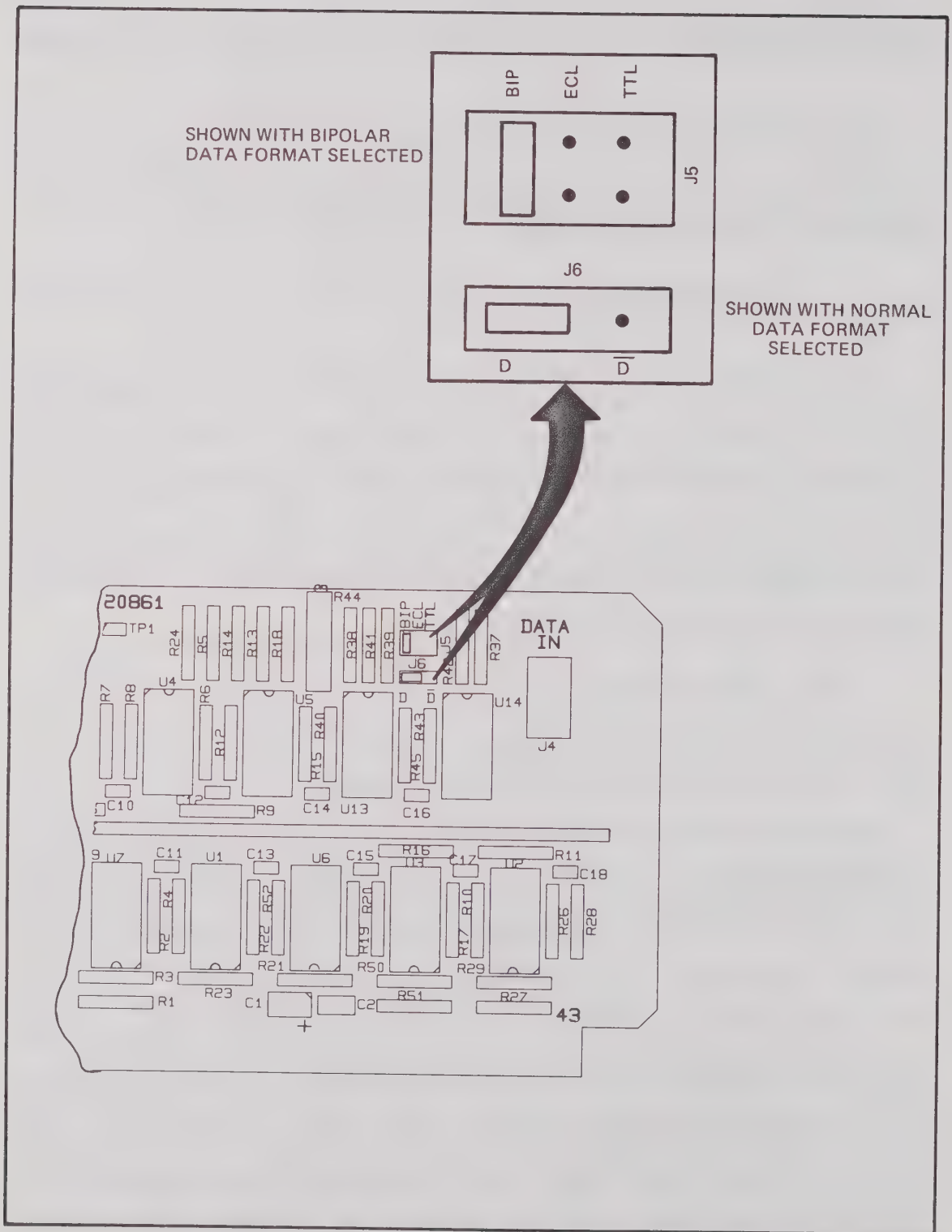


Figure 3.6. NRZ CLOCK and DATA Format Selections

now be removed, jumpered as desired, and returned to their respective positions. Figure 3.7 shows the timing requirement between CLOCK and DATA signals for the NRZ inputs.

2. DS3 Input Connector and Associated Switches

The DS3 data input connector is compatible with WECo Type 440A, or equivalent. Pressing the INPUT switch while in stop mode selects the input signal level to be expected, either LO/HI or DSX-3. Signals through the DS3 input connector are applied to an automatic gain control amplifier circuit when the LO/HI input type is selected. Selecting the DSX-3 input type directs input signals through an equalizer network to compensate for 450 feet of Type 728A cable. This feature will, in turn, compensate for the cable simulator in the DSX-3 output from a Model 4651A BERTS Transmitter.

No switching is provided or required to operate with either DS3 or NRZ data inputs but only one type of input can be connected at a time for proper operation.

3. External Event Monitor

The External Event MONITOR inputs consists of two DC VOLTAGES and two DRY CONTACT inputs, located on the rear panel. This connector is shown in Figure 3.8.

G. Print Control

1. Triggered Printout

The PRINT DCV/BER switch directly selects how a printout is triggered and indirectly selects what data is printed according to Table 3.2. Note that BER Data is always printed.

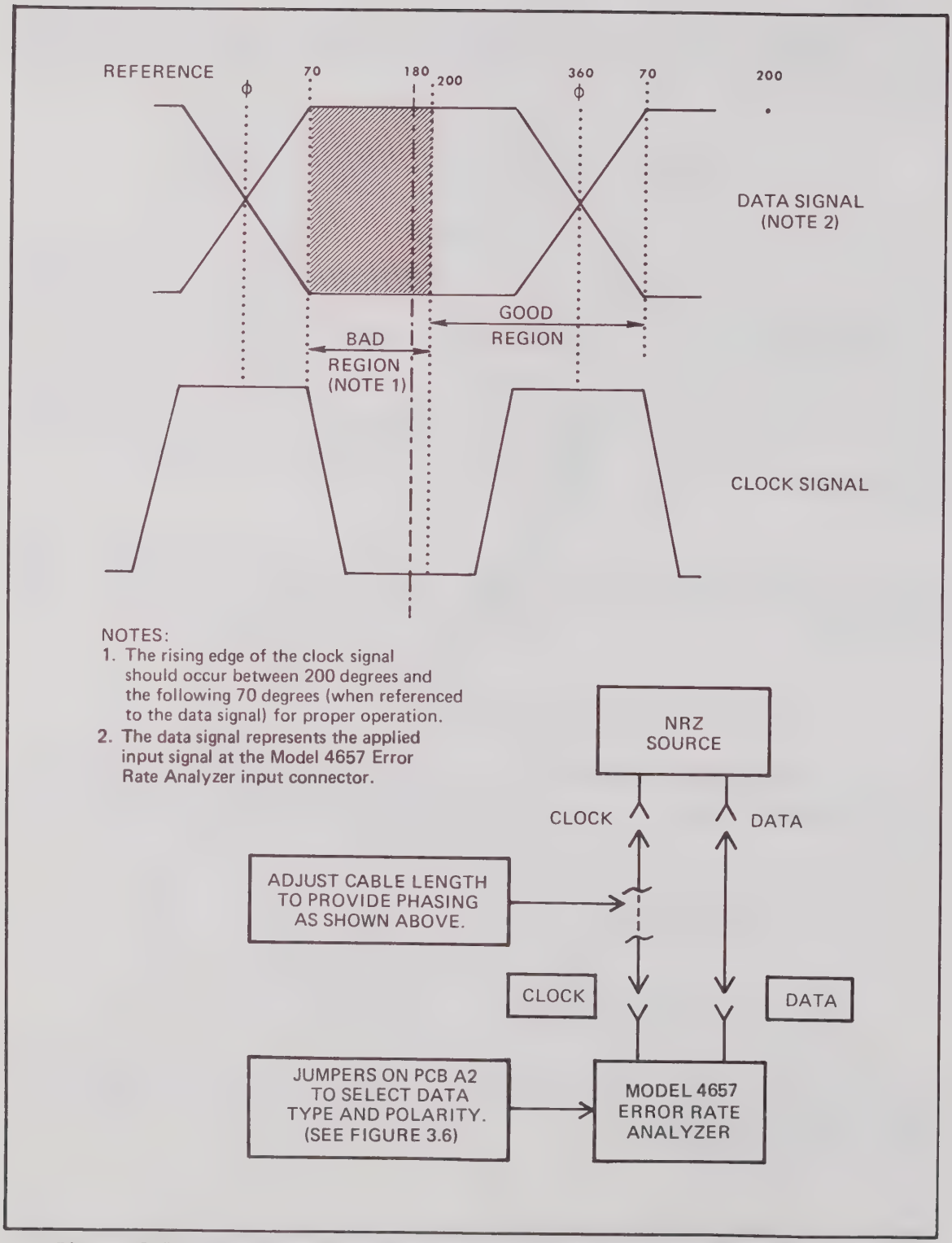


Figure 3.7. Clock and Data Timing Relationship for NRZ Input Signals

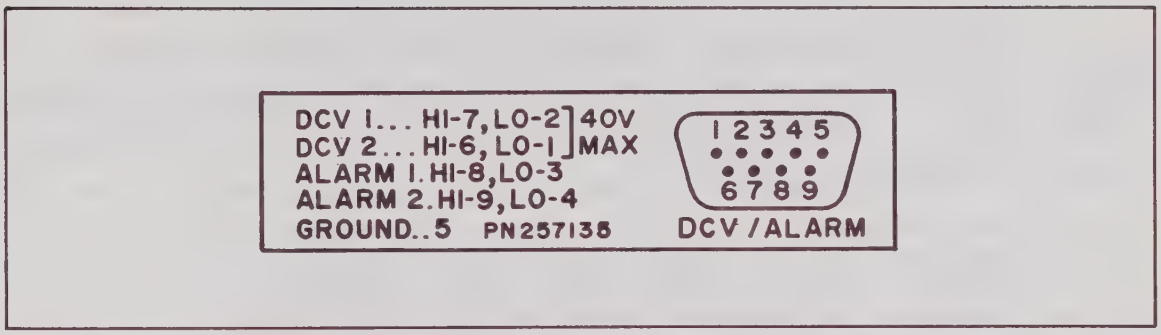


Figure 3.8. External Event Monitor Input Connector

Table 3.2
Conditions Triggering Printouts

	Trigger on DCV (DCV LED on)	Trigger on BER (BER LED on)	Trigger on Either (Both LEDs on)
DCV Data Printed	✓	X	✓
BER Data Printed	✓	✓	✓

2. Forced Printout

Pressing the LO/HI/DSX-3 switch while the SHIFT switch is also pressed will produce a Test Result Printout on the Local Printer. This function is available both during and after tests.

3. Printout Format

When pressed with the SHIFT switch held in, the PRINT FORMAT switch controls the format of the message from the local printer. If the ALL LED is illuminated, then the printer will log all errors in all thresholds along with BURST measurements. If the PART LED is illuminated, then only errors in the selected threshold are displayed. An ALL printout will result for test ending printouts and forced prints for all tests over five minutes regardless of the ALL/PART selection.

H. Additional Functions

1. SELF-TEST

A SELF-TEST is initiated by the attempt to enter a negative value for the MONTH and DAY. That is, with the SHIFT switch held in, simply press the ELAPSED switch (-) and then the MONTH-DAY switch (SET). The SELF-TEST performs the following operations:

(1) RTC TEST - The Real Time Clock Circuitry is tested.
(2) RAM TEST - Internal Random Access Memory is tested.
(3) ROM TEST - Internal Read Only Memory is tested.
(4) The Scientific-Atlanta Firmware Number (Part No.) is displayed.
(5) The audible alarm is tested. (A tone should be heard.)
(6) A LAMP TEST is executed. At this time the RESET switch may be pressed if a PRISTINE RESET is desired.

The SELF TEST can only be entered from the STOP MODE. Items 1, 2, 3 and 6 are also done at power-up. Messages will only be displayed on power-up if there is a failure.

2. Blinking LEDs

The following is a summary of the LEDs which blink and the significance of their blinking.

(1) A blinking TIME-OF-DAY, ELAPSED, SINGLE, REPEAT, HI DC THRESHOLD, or LO DC THRESHOLD LED signifies that the SET MODE has been entered and that the operator is expected to (a) enter more numbers into the TIME display, (b) exit the SET MODE by pressing the switch under the blinking LED (SHIFT must be pressed in to enter TIME-OF-DAY), or (c) exit the SET MODE by pressing the MONTH-DAY switch while holding in the SHIFT switch, thus entering the numbers in the display as the month and day.
(2) The GATING LED blinks when the display is updated with new information.
(3) The status LEDs (SIG LOSS, FRAME LOSS, PRBS LOSS, IN 1 and IN 2 DC Threshold) blink after a test has been stopped to indicate that their status condition occurred at some time during the timed test.
(4) A blinking RUN LED indicates that either a POWER LOSS or a status condition has occurred at some time during the test. The status conditions not only include all those with status LEDs, but also the two dry contact alarms.
(5) A blinking STOP LED indicates that a POWER LOSS has occurred.

3.5 OPERATION - MODEL 4650 PRINTER

A. General

The Model 4650 Printer is an option and, when provided, can make permanent records of measured results. During the RUN mode, errors will be logged whenever they occur. During a TIMED mode, data will also be logged whenever the analyzer timer counts to 0. Also, the PRINT button can be used to force a printout at any time. If, in either mode, a SIGNAL LOSS, PRBS LOSS, or FRAME LOSS occurs, the time when the condition occurred and the time when the condition was recovered will both be logged. Blue signal is also logged in a similar manner. Also, changes in DC DRY CONTACT status and DC OUT OF THRESHOLD status will be logged. A frame lock, PRBS lock, signal lock, or blue signal will only be logged if they last for a minimum of one second. If there is PRBS LOSS when entering RUN mode, PRBS lock and LOSS messages will not be printed. Also, bit data will not trigger printouts or be printed. This facilitates testing on live traffic.

B. Installation

The Model 4650 Printer receives its operating power and command signals through the provided Interface cable when connected to a Model 4657 Error Rate Analyzer. It is recommended that the Error Rate Analyzer POWER switch be operated off (down position) before attaching the interface cable to the rear panel connector labeled "LOCAL PRINTER". The Model 4650 Printer may be placed on top of or beside the Model 4657 Analyzer leaving sufficient space around it to allow normal paper feed out of the printer and normal air flow through the Error Rate Analyzer.

C. Operation

1. Self-Test Mode

If the Model 4650 Printer is to be used after a period of storage and/or a self-check is desired after being transported between analyzer locations, use the following sequence:

a. Apply power to the associated Model 4657 Error Rate Analyzer.
b. Operate the Model 4650 Printer POWER switch to OFF.
c. Press and hold PAPER ADVANCE switch, then operate printer POWER switch to ON. The printer will provide a full character set as a self-test.
d. Release PAPER ADVANCE switch.

2. Log When Errors Occur

Condition the Model 4657 Analyzer to make an ELAPSED time test as described in Section 3.4. After this is accomplished and when the analyzer STOP indicator is illuminated, operate the Model 4650 Printer POWER switch to ON. Now operate the Model 4657 Analyzer to RUN. This starts the analyzer timer and whenever an error occurs, the time will be logged. The three error types will be totaled and printed using any of the measurement modes. A maximum length message printout is shown in Figure 3.9a.

A feature is provided to avoid printing superfluous readings during high error rate conditions. If the error rate is sufficiently high as to cause 10 consecutive error-seconds, error printing is suppressed. After the error condition is corrected, logging features return to log on each error as before, provided the last 10 seconds are error-free. In printouts generated during a test, the AVG BER measurement is actually the worst 1-second average since the last printout.

3. Log on Preset Interval

Configure the Model 4657 Analyzer to make a SINGLE TIMED or REPEAT TIMED test as described in Section 3.4. After this is accomplished and when the analyzer STOP indicator is illuminated, operate the Model 4650 Printer POWER switch to ON. Now operate the Model 4657 Analyzer to RUN. Each time the timer counts to 0, a new log is made. During the SINGLE TIMED mode, only one log will be made and during the REPEAT TIMED mode, logs will be made at each 0 count until the timer is stopped. Logs will also be made on the occurrence of an error. Note also that if the REPEAT TIMED mode is selected with a cycle time of only a few seconds, some logging intervals may be skipped.

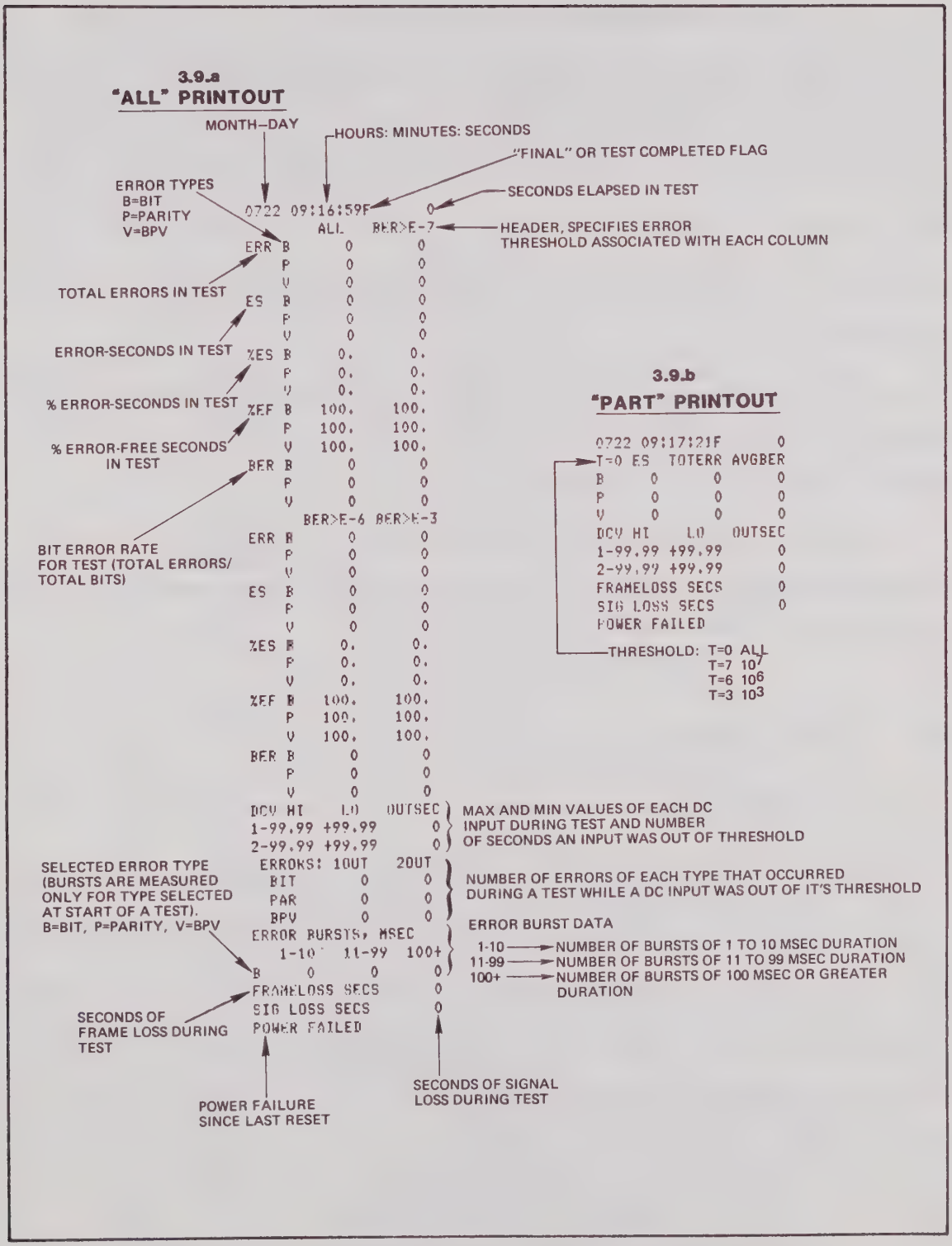

3.9.a
"ALL" PRINTOUT
MONTH–DAY
HOURS: MINUTES: SECONDS
"FINAL" OR TEST COMPLETED FLAG
ERROR TYPES
B=BIT
P=PARITY
V=BPV
SECONDS ELAPSED IN TEST
0722 09:16:59F 0
ALL BER>E-7
HEADER, SPECIFIES ERROR THRESHOLD ASSOCIATED WITH EACH COLUMN
TOTAL ERRORS IN TEST
ERROR-SECONDS IN TEST
% ERROR-SECONDS IN TEST
% ERROR-FREE SECONDS IN TEST
BIT ERROR RATE FOR TEST (TOTAL ERRORS/ TOTAL BITS)
ERR B 0 0
P 0 0
V 0 0
ES B 0 0
P 0 0
V 0 0
%ES B 0. 0.
P 0. 0.
V 0. 0.
%EF B 100. 100.
P 100. 100.
V 100. 100.
BER B 0 0
P 0 0
V 0 0
BER>E-6 BER>E-3
ERR B 0 0
P 0 0
V 0 0
ES B 0 0
P 0 0
V 0 0
%ES B 0. 0.
P 0. 0.
V 0. 0.
%EF B 100. 100.
P 100. 100.
V 100. 100.
BER B 0 0
P 0 0
V 0 0
DCV HI LO OUTSEC
1-99.99 +99.99 0
2-99.99 +99.99 0
MAX AND MIN VALUES OF EACH DC INPUT DURING TEST AND NUMBER OF SECONDS AN INPUT WAS OUT OF THRESHOLD
SELECTED ERROR TYPE (BURSTS ARE MEASURED ONLY FOR TYPE SELECTED AT START OF A TEST). B=BIT, P=PARITY, V=BPV
ERRORS: 1OUT 2OUT
BIT 0 0
PAR 0 0
BPV 0 0
NUMBER OF ERRORS OF EACH TYPE THAT OCCURRED DURING A TEST WHILE A DC INPUT WAS OUT OF IT'S THRESHOLD
ERROR BURSTS, MSEC
1-10 11-99 100+
B 0 0 0
ERROR BURST DATA
1-10 → NUMBER OF BURSTS OF 1 TO 10 MSEC DURATION
11-99 → NUMBER OF BURSTS OF 11 TO 99 MSEC DURATION
100+ → NUMBER OF BURSTS OF 100 MSEC OR GREATER DURATION
FRAMELOSS SECS 0
SIG LOSS SECS 0
POWER FAILED
SECONDS OF FRAME LOSS DURING TEST
POWER FAILURE SINCE LAST RESET
SECONDS OF SIGNAL LOSS DURING TEST
3.9.b
"PART" PRINTOUT
0722 09:17:21F 0
T=0 ES TOTERR AVGBER
B 0 0 0
P 0 0 0
V 0 0 0
DCV HI LO OUTSEC
1-99.99 +99.99 0
2-99.99 +99.99 0
FRAMELOSS SECS 0
SIG LOSS SECS 0
POWER FAILED
THRESHOLD: T=0 ALL
T=7 10^7
T=6 10^6
T=3 10^3

Figure 3.9. A Message Printout from a Model 4650 Printer

4. Log Formats

The PRINT DCV/BER and ALL/PART switch on the Model 4657 Analyzer, in conjunction with the ERROR THRESHOLD switch, controls the quantity and format of the data printed in each logging operation, see Section G: PRINT CONTROL. Figure 3.9a is the result of a Print command with PRINT ALL selected and an ERROR THRESHOLD for ALL. In this mode, the entire measurement repertory is printed: all measurements, all thresholds. If one of the other ERROR THRESHOLDs were selected, only the ALL and the selected threshold data would be printed.

Figure 3.9b is the result of a Print command with PRINT PART selected. Only data pertaining to the selected error threshold is printed. Burst measurement information is not printed.

Notice the POWER FAILED message on the printout in Figure 3.9a. This occurs during force prints and test ending printouts if there has been a power failure since the last RESET.

3.6 REMOTE OPERATION

A. General

The Model 4657 Analyzer is available with two different remote interface options: IEEE-488 and RS-232C. Although they are physically different, the commands available to the programmer are the same. Differences do arise, however, with interface dependent commands. A GET or a Parallel Poll are physically impossible for RS-232C but are valid commands for IEEE-488. Commands and features that are valid for only one of the interface options are noted in the text and tables. Only one interface may be installed in the analyzer at any one time.

Table 3.3 lists the code assignments for a Model 4657 Analyzer operating under remote control. Each command conists of several ASCII characters followed with a valid delimiter. Valid delimiters are commas, semicolons, carriage return (CR), and line feed (LF). It is presumed that the user of the following commands is familiar with the interface standard and the interface has been properly installed.

Table 3.3
Remote Operation Input Command Definitions

Code Letter	Function Title	Descriptions and Subfunctions "n" (where "n" is identified by a number)
Cn	Clear	C1 = Set mode in STOP, Restart in RUN C2 = Clear Accumulators, Reset in STOP, Restart in RUN C3 = Both (C1 and C2)
CL	Device Clear	Clears the remote interface.
Dn	Select ERROR Type	D1 = BIT Error D2 = PARITY Error D3 = BIPOLAR VIOLATION Error
En	Select RS-232C Echo	E1 = Echo Off E2 = Echo On (Does not affect IEEE-488 Operation.)
FP	Force Print	Forces a printout on the local printer.
GL	Enable Front Panel	Allows the front panel keyboard to be active (default state). Does not affect IEEE-488 Operation. Also disables remote.
Hn	INPUT Signal Select	H1 = LO/HI H2 = DSX-3
Jn	RUN/STOP	J1 = STOP J2 = START J3 = Start Standard ELAPSED Test (Note 1) J4 = Start Standard TIMED Test (Note 2)
Kn	Parallel Poll Configuration	K1 through K8 assign parallel poll to bits 1 through 8, respectively. Does not affect RS-232C Operation. KØ clears all bits.

Table 3.3 - continued

Code Letter	Function Title	Descriptions and Subfunctions "n" (where "n" is identified by a number)
LL	Disable Front Panel	Disables the front panel keyboard. Does not affect IEEE-488 Operation.
Mn	ERROR Display Mode	M1 = TOTAL ERROR SECONDS M2 = % ERROR SECONDS M3 = TOTAL ERRORS M4 = AVERAGE BER M5 = ERRORS/10^7 Bits M6 = ERRORS/10^8 Bits M7 = DC MONITOR IN 1 M8 = DC MONITOR IN 2
N	Enter Time or DC Threshold Value	Enter four digits for Month/Day, six digits for Time, or four digits plus decimal point and minus sign for DC thresholds.
PLn	Printer Select (Note 4)	PL1 = ALL Printout PL2 = PART Printout
Qn	Data Request	Q1 = Dump measurement for all three error types Request (B, P, V) and DC Monitor. The length, format and content are controlled by the ERROR THRESHOLD (THn), Length (XLn) and Format (XFn) selected. Q2 = Dump current time, elapsed time, and time remaining as applicable to current test. The format is controlled by XFn. Q3 = Dump analyzer status. Status is current while in RUN mode and history while in STOP mode. Q4 = Dump measurements for only the error type selected (Dn command) or DC Monitor. The length, format and content are controlled by the ERROR THRESHOLD (THn), Length (XLn) and Format (XFn) selected. Q5 = Dump Error Burst measurements. The format is controlled by XFn. Q6 = Not used on this unit. Q7 = Power-Down and Power-Up Times.
RE	Enable Remote Operation	Changes the unit status to remote. Required for RS-232C operation as unit will not respond to any commands unless it is in the remote state.

Table 3.3 - continued

Code Letter	Function Title	Descriptions and Subfunctions "n" (where "n" is identified by a number)
RD	Disable Remote Operation	Changes the unit status back to local operation. Does not affect IEEE-488 operation.
Sn	Set Clock to Entered Value	S1 = Set MONTH-DAY to entered value S2 = Set TIME OF DAY to entered value
SR	Serial Poll Acknowledge	Allows the unit to reset the serial poll status.
THn	ERROR THRESHOLD Select (Note 3)	TH1 = ALL TH2 = 10^{-7} TH3 = 10^{-6} TH4 = 10^{-3}
Tn	Select TIME Display Mode	T1 = MONTH-DAY Display T2 = TIME OF DAY Display T3 = ELAPSED-TIME Display T4 = SINGLE-TIMED Display T5 = REPEAT-TIMED Display T6 = HI DC THRESHOLD T7 = LO DC THRESHOLD
WY	Identify	Returns unit identification. ETX before the last CR/LF will indicate the last three bytes. EOI will be set for IEEE-488 operation.
XFn	FORMAT Select	XF1 = Select "machine" mode for output formatting (see examples in Section E). XF2 = Select "human" mode for output formatting (same as printer option format).
XLn	LENGTH Select (Note 4)	XL1 = ALL Printout on Remote Interface. XL2 = PART Printout on Remote Interface.
XMn	Log MODE	XM1 = Log on request only (Note 5) XM2 = Auto log in sequence TOTAL & % Error-Seconds; TOT ERR, AVG BER, DC IN 1, DC IN 2.
XPn	Printout Trigger	XP1 = Trigger on DCV out of threshold XP2 = Trigger on Errors XP3 = Trigger on either DCV out of threshold or Errors

Table 3.3 - continued

Code Letter	Function Title	Descriptions and Subfunctions "n" (where "n" is identified by a number)
XTn	TIME Line Select	XT1 = No TIME line with data. XT2 = Output real TIME and date with data.

NOTES:

1. Standard ELAPSED Test: Automatically formats and performs C2 (Clear accumulators), TH1 (ALL Threshold), T3 (ELAPSED time display), C1 (SET mode, clear display), T3 (set ELAPSED time display), D2 (display PARITY ERROR), M1 (display TOTAL ERROR SECONDS), XM2 (auto log), XT2 (provide real TIME with transmitted data), and J2 (start Timer and operate RUN to on).

2. Standard TIMED Test: Must be preceded with T4 or T5 to select timer to be set, an N (a Time value) and T4 or T5 to set the timer. The system then automatically formats and performs C2 (Clear all accumulators and reset), D2 (display PARITY ERROR), M1 (display TOTAL ERROR SECONDS), TH1 (ALL Threshold), XM2 (auto log), XT2 (provide real TIME with transmitted data), and J2 (start Timer and operate RUN to on).

3. ERROR THRESHOLD does not affect data acquisition, but how acquired data is displayed. Each ERROR SECOND is categorized as to which thresholds its average BER exceeds. When a threshold is selected, only errors occurring in seconds for which the average BER exceeded that threshold will be considered in computing the measurement values.

4. If the ALL printout is selected, the selected ERROR THRESHOLD affects the data printed as follows: If the ALL threshold is selected, results for all four thresholds are printed. If a threshold other than ALL is selected, results for the selected threshold and the ALL threshold are printed. If the PART printout is selected, only the results for the selected threshold are printed. If a test lasts over five minutes, test ending printouts and force prints will be ALL format regardless of selection.

5. The XM1 command (Log on request only) should generally be issued to prevent AUTO LOG results from being confused with the results of a Request for Data.

B. IEEE-488 Interface Option

1. Installation

The IEEE-488 Interface option (Part No. 257189) can be installed in the Model 4657 Analyzer during a routine maintenance check if desired. The

IEEE-488 Interface Bus printed circuit board must be installed in the correct card cage assembly slot as shown in Figure 3.10. Before inserting the printed circuit board, observe the DIP switch (upper right hand corner) for correct Bus Device Address switch settings. Addressing is straight binary coding as shown in Figure 3.11. The Model 4657 Analyzer can be configured as a "talker/listener" or in "talk only" mode for direct logging of measurements on a bus compatible printer. It can not be configured as a system controller. When the switch code is verified to be correct, install the printed circuit board securely in the proper slot connector.

Remove the bottom cover from the analyzer. Properly route the interconnecting flat cable (Cable Assembly W11) by passing the smaller connector end from the outside and through the rear panel hole labeled "IEEE-488". The connector should be oriented so the wide part will be closest to the analyzer top cover. Attach the connector to the rear panel with hardware supplied. Run the cable flat, across the bottom of the card cage assembly, then up and through the front of the card cage assembly, connecting it to the A8 printed circuit board.

Replace the analyzer bottom cover. Perform a visual check that cables, etc. are correctly positioned. Remount the card cage assembly retainer. Replace the analyzer top cover. The equipment is now ready for bus operation.

2. Special Features of IEEE-488 Interface

a. Parallel Poll Configure

Parallel polling is used on the IEEE-488 Bus to allow up to eight interface compatible equipments to return a one-bit status to the system controller. An active parallel poll bit indicates that a unit is in need of service by the system controller. Obviously, each unit is assigned different bit locations to use during parallel poll to avoid conflicts. The Model 4657 Analyzer can only be indirectly configured for bit location during parallel polls. Note that in Table 3.3, the letter K is used for parallel poll configuration. After the system controller has addressed the Model 4657 Analyzer to

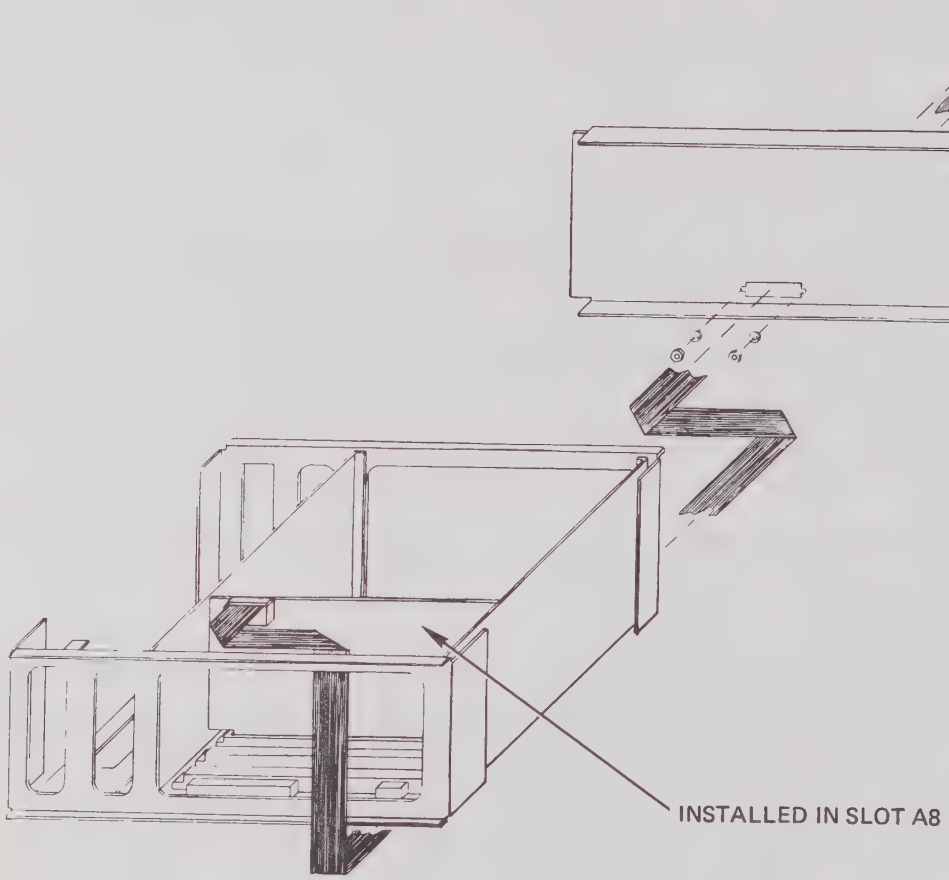
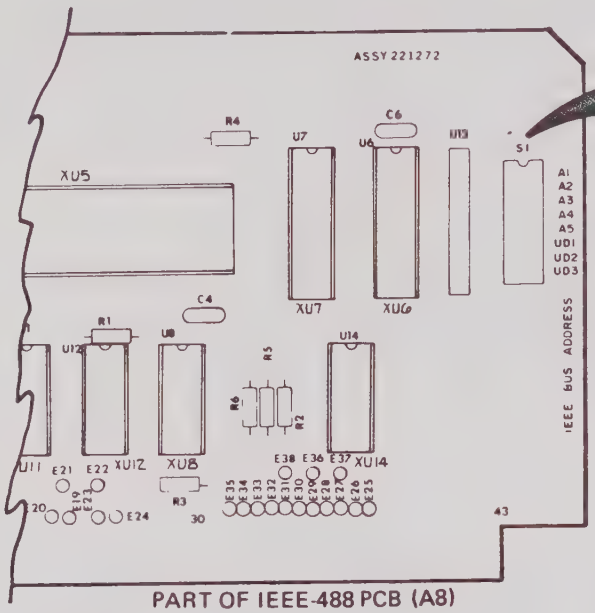
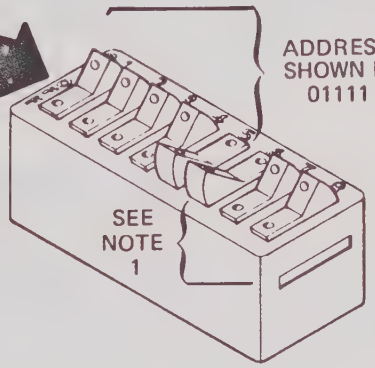


Figure 3.10. Part Number 257189 Assembly, IEEE-488 Interface



PART OF IEEE-488 PCB (A8)



IEEE-488 ADDRESS
SELECTION SWITCHES
(OFF=1/ON=0)

NOTES:

1. SWITCH POSITIONS UD3, UD2, UD1 MUST BE SET TO "0, 0, 0" FOR "TALK/LISTEN MODE" OR TO " 1, 0, 0" FOR "TALK ONLY MODE."
2. THESE COLUMNS IDENTIFY THE BUS ADDRESS IN BOTH HEXIDECIMAL AND DECIMAL.

Bus Address (Note 1)		A5	A4	A3	A2	A1	← PCB Reference	A5	A4	A3	A2	A1	Bus Address (Note 1)	
HEX	DEC	5	4	3	2	1	← Switch Number	5	4	3	2	1	HEX	DEC
01H	01	0	0	0	0	1		1	0	0	0	0	10H	16
02H	02	0	0	0	1	0		1	0	0	0	1	11H	17
03H	03	0	0	0	1	1		1	0	0	1	0	12H	18
04H	04	0	0	1	0	0		1	0	0	1	1	13H	19
05H	05	0	0	1	0	1		1	0	1	0	0	14H	20
06H	06	0	0	1	1	0		1	0	1	0	1	15H	21
07H	07	0	0	1	1	1		1	0	1	1	0	16H	22
08H	08	0	1	0	0	0		1	0	1	1	1	17H	23
09H	09	0	1	0	0	1		1	1	0	0	0	18H	24
0AH	10	0	1	0	1	0		1	1	0	0	1	19H	25
0BH	11	0	1	0	1	1		1	1	0	1	0	1AH	26
0CH	12	0	1	1	0	0		1	1	0	1	1	1BH	27
0DH	13	0	1	1	0	1		1	1	1	0	0	1CH	28
0EH	14	0	1	1	1	0		1	1	1	0	1	1DH	29
0FH	15	0	1	1	1	1		1	1	1	1	0	1EH	30
								1	1	1	1	1	1FH	31

(continued in next column)

Figure 3.11. IEEE-488 Interface Printed Circuit Board (A8), Bus Address Codes

be a listener, it then issues a K1 or K2 (through K8) command to assign the parallel poll bit location. When the analyzer is powered-up after a shutdown condition, it automatically selects the parallel poll bit that was selected before power-down.

b. Serial Poll Bit Assignment

The Serial Poll is activated by the system controller enabling the Serial Poll Mode State and then addressing an individual device to put its status bits on the bus. This allows each unit on the bus to respond to the system controller with up to eight unique status bits. The Model 4657 Analyzer uses these bits for Signal Loss, Framing Loss, Secondary Alarm, Measurement Complete, Command Errors, Data Present, SRQ Active and RUN mode as shown in Figure 3.12. A logic "1" indicates the condition is true. A Command Error is an unrecognized command to the Model 4657 Analyzer or a currently invalid command. For example, the analyzer will not accept an "L1" which is not an input command. Secondary Alarms are PRBS Loss, Power Loss, DC out of threshold, or Alarm Input active. See note in Section 3.6E.

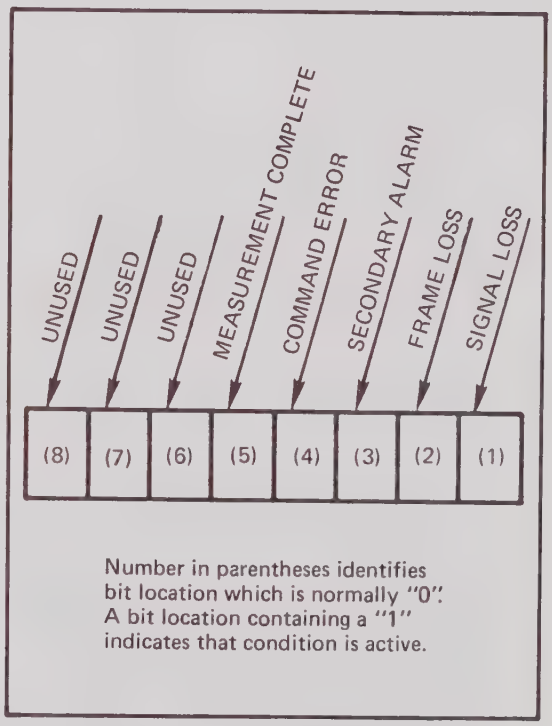


Figure 3.12. Serial Poll Bit Assignment

c. Group Execute Trigger (GET) and Device Trigger

The Group Execute Trigger (GET) and Device Trigger signals are used to let devices on the bus, either individually or in groups, be triggered or to start some action. As applied to the Model 4657 Analyzer, a received GET or Device Trigger signal is equivalent to issuing a J2 (RUN) command.

d. Device Clear or Selective Device Clear

A Device Clear or Selective Device Clear signal addressed to the Model 4657 Analyzer is equivalent to a power-up restart except the IEEE-488 Interface is not reconfigured.

e. Service Request

The Service Request signal lets the equipment indicate to a system controller that an event has occurred, and requests the controller to take some specific action. The normal procedure after receiving a Service Request is for the system controller to perform a Parallel Poll to determine which equipment or device requires service, and then performs a Serial Poll to determine which event within the equipment or device has occurred that needs service. Serial Poll assignments applicable to the Model 4657 Analyzer are provided in Section "b. Serial Poll Bit Assignment" and in Figure 3.12. A Service Request signal is initiated whenever any of these conditions change status, except the Command Error and Data Present, which only requests service when switched "True" and RUN mode which never activates the Service Request signal.

f. Talk Only

In dedicated applications where an IEEE-488 Bus compatible printer or logging device is available to record the error measurements, and there are no other devices on the bus, then a system controller is not required. The Model 4657 Analyzer can be configured to the "talk-only" mode, and the associated printer to the "listen-only" mode, and error measurements can be directly recorded. The analyzer would be operated manually through front panel controls

but measurement data would still be output over the Bus for recording. See Figure 3.11 for instructions to establish the "Talk Only" mode of operation.

C. RS-232C Interface Option

1. General

The RS-232C Interface for the Model 4657 is available as Part Number 257190. This option is a serial interface through which all front panel functions can be controlled, measurements can be stopped and started, data requests can be made, and error logging can be provided. The interface software is written to accept commands that can easily be generated by an operator from an RS-232C compatible data terminal. These commands can also be generated by an automatic data collection system under computer control.

Input commands to the Model 4657 Analyzer consist of a series of letters and numbers corresponding to front panel switches, so that receiving these combinations is equivalent to an operator pressing the switch. For example, "T2" selects the TIME OF DAY mode, "D1" selects BIT ERROR for display, etc. But there are also commands which have no direct equivalent to front panel switches, such as Request for Real-Time, Time Remaining, and Elapsed-Time Request (Q2), etc.

Using the RS-232C Interface Option, the operator can command a measurement from the Model 4657 Analyzer and have the results of that measurement printed out at the terminal, whether the terminal is adjacent to the analyzer or operating miles away through a voice quality data modem. The local Printer, Option 4650, can be operated simultaneously with the RS-232C Interface Option to provide remote and local logging of measured results.

If the Model 4657 Analyzer is in the remote disabled mode (RD), the RS-232C Interface will function in a "talk-only" mode where its output data is identical to the local printer (Model 4650) output data.

2. Installation

The RS-232C Interface option can be installed in the Model 4657 Analyzer during a routine maintenance check if desired. The RS-232C Interface printed circuit board must be installed in the correct card cage assembly slot as shown in Figure 3.13. Before inserting the printed circuit board, the data rate must be set to equal the data modem and terminal with which the Model 4657 Analyzer will operate. The data modem used in this service must also be compatible with the Model 4657 Analyzer and associated terminal. This generally requires only that the Modem use full duplex with RS-232C input/output capabilities.

Setting the data rate requires removing the Error Counter 2/3 printed circuit board (A7) from the card cage assembly and providing the proper jumper combination. The data rate/jumper requirement is shown in Figure 3.14. When the data rate has been set, return the A7 printed circuit board to its original location.

Remove the bottom cover of the analyzer. Properly route the interconnecting flat cable (Cable Assembly W12) by passing the smaller connector end from the outside and through the rear panel hole labeled "RS 232C". The connector should be oriented so the wide part will be closest to the analyzer top cover. Attach the connector to the rear panel with hardware supplied. Run the cable flat across the bottom of the card cage assembly, then up and through the front of the card cage assembly, and then connect to the A8 printed circuit board.

Replace the analyzer bottom cover. Perform a visual check that cables, etc. are correctly positioned. Remount the card cage assembly retainer. Replace the analyzer top cover, and the equipment is ready for RS-232C operation.

When operating through a modem, the Model 4657 Analyzer will be set up as Data Terminal equipment; and when operating directly to a terminal, it must be configured as Data Set equipment, which only requires reversing the Transmitted Data and Received Data signal leads. There may be an installation where,

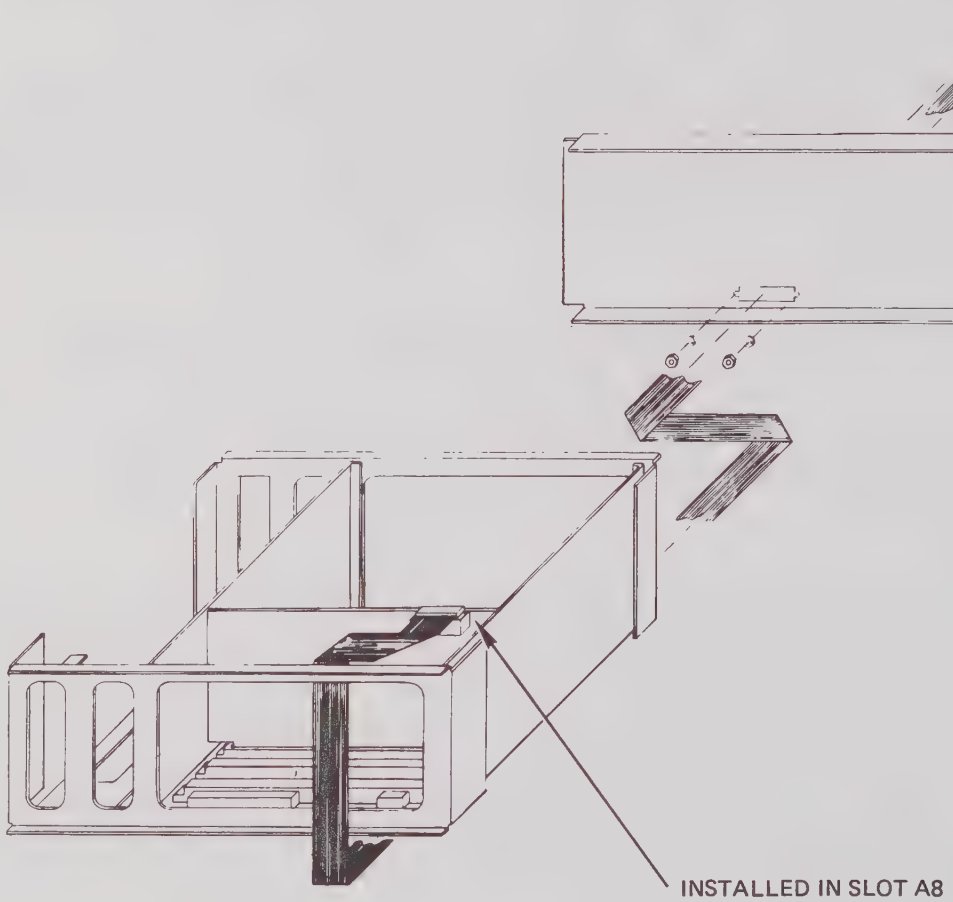


Figure 3.13. Part Number 257190 Assembly, RS-232C Interface

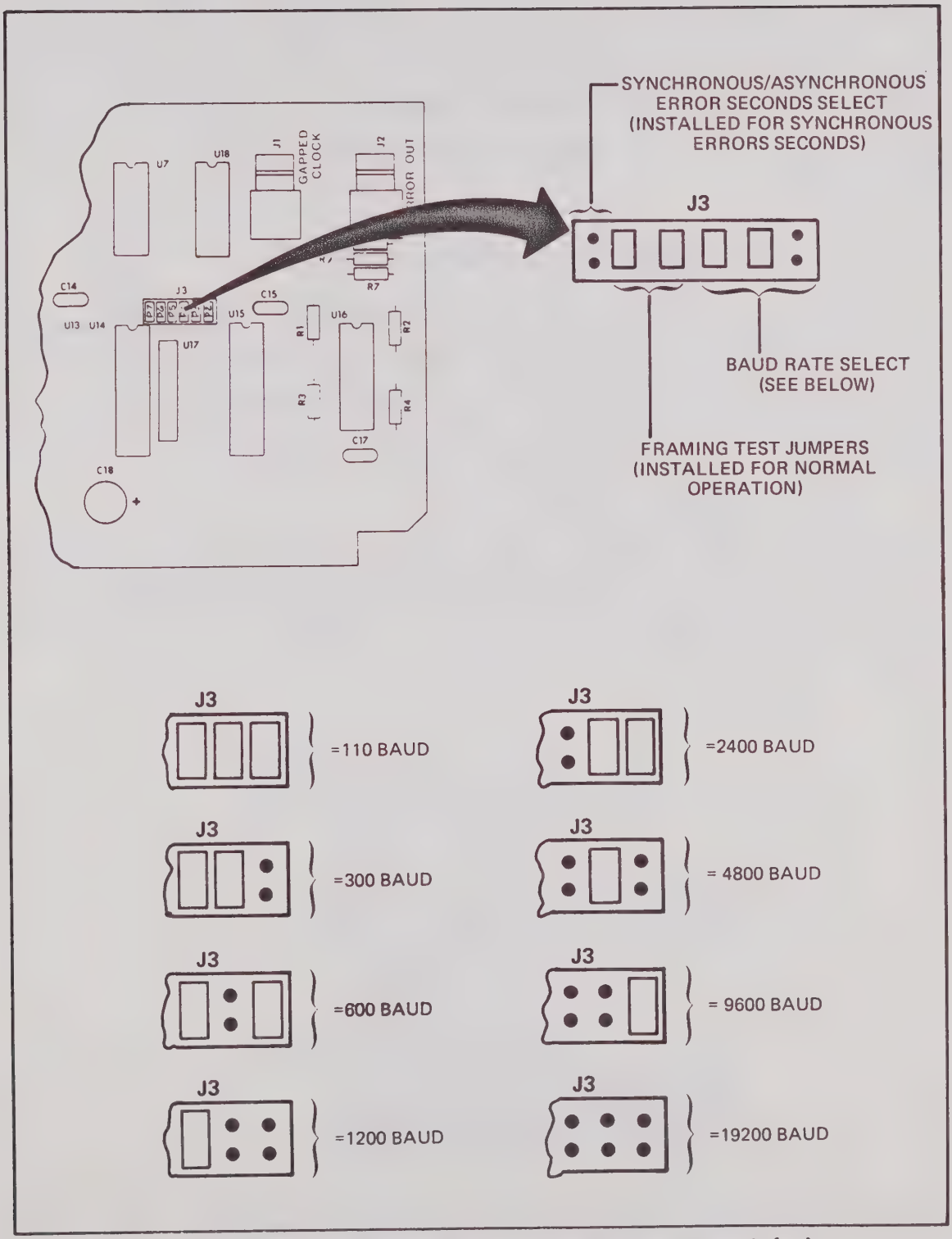


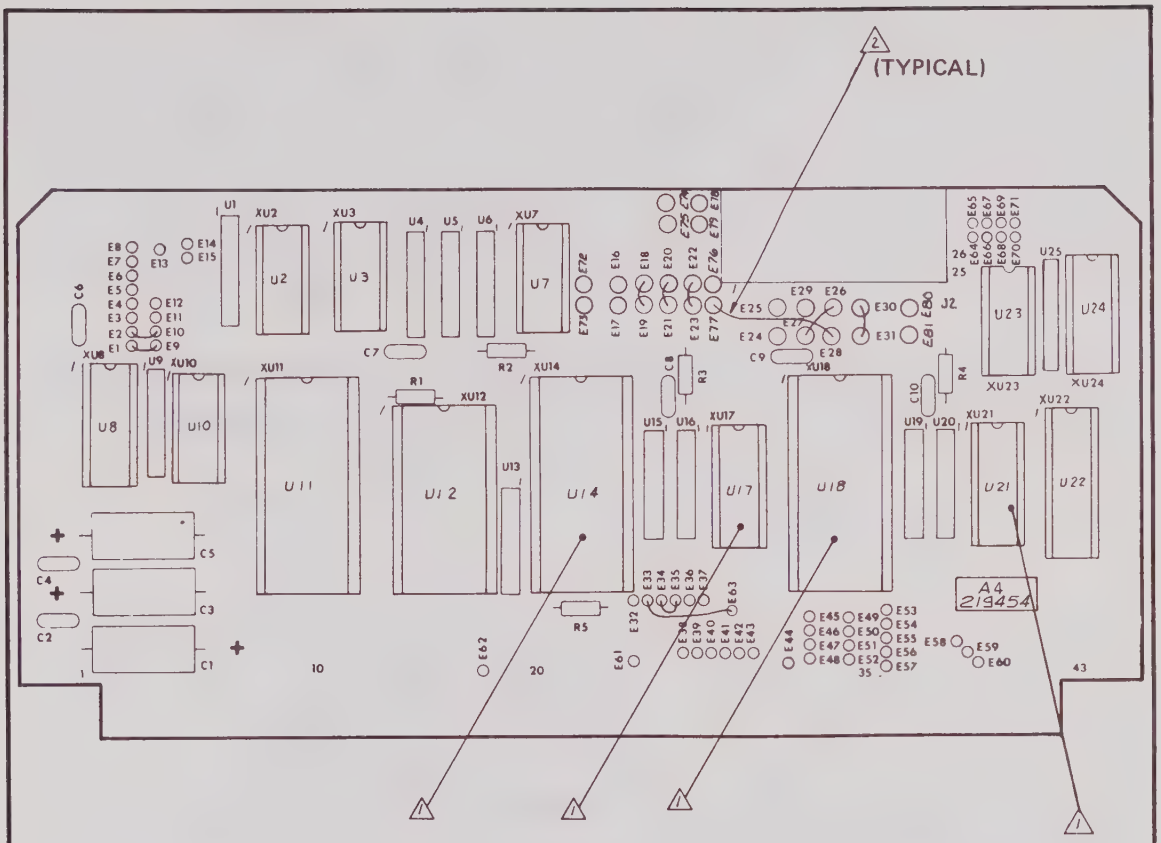
Figure 3.14. Error Counter 2/3 Printed Circuit Board (A7), Selection of RS-232C Data Rate

because of the terminal being used, the functions DTR, CTS, RTS, and DSR need to be connected. These connections are shown in Figure 3.15. The Model 4657 Analyzer does not require the use of the modem handshaking lines. If the modem is "auto answer", the analyzer is always ready to send; and if the modem is not ready, the analyzer will have no input and the analyzer output will be dumped.

3. Special Features of RS-232C Interface

There are two operating modes for the RS-232C interface. After power is applied to the analyzer, it defaults to Full duplex operation. Full duplex implies there can be simultaneous data flow in both directions. Echo-Plex is available through the Echo command. This implies the unit will transmit back (echo) any character that is received.

Before any RS-232C commands can be accepted, a Remote Enable command must be sent to the unit. XON and XOFF (RS-232C commands) are implemented and may be used to control data flow from the unit. A typical serial RS-232C signal format is shown in Figure 3.16.



NOTES:

1. U14, U17, U18, U21 not used.

2. Install the following jumpers for all RS-232C boards:
   E1 - E9 E33 - E63
   E2 - E10 E34 - E35
   E3 - E38

3. Install the following jumpers as required for RS-232C option (E26 - E27 connects Signal Ground):
   DCE (For BERTS connection to RS-232C compatible printer)
   E23 to E20
   E21 to E22
   DTE (For BERTS connection to Modem)
   E21 to E20
   E23 to E22
   Other RS-232C option jumpers:
   DTR: E30 to E28 for DCE; E30 to E31 for DTE
   DSR: E29 to E31 for DCE; E29 to E28 for DTE
   RTS: E19 to E16 for DCE; E19 to E18 for DTE
   CTS: E18 to E17 for DCE; E17 to E16 for DTE
   CAR DET: E77 to E78 and E14 to E15 for DCE

Figure 3.15. RS-232C Interface Printed Circuit Board (A8), Jumper Connections for Normal Operation

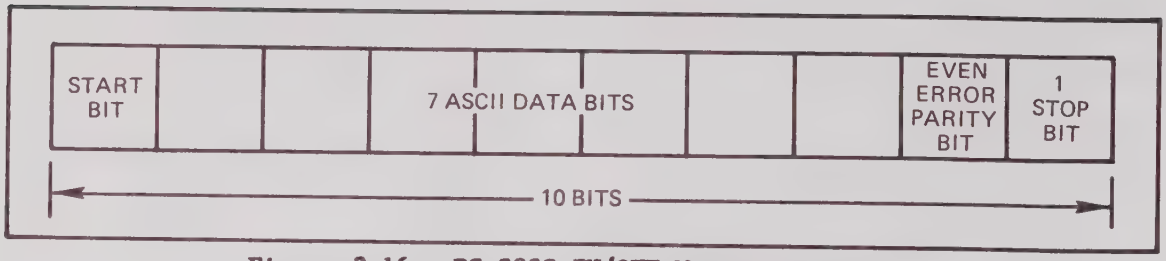


Figure 3.16. RS-232C IN/OUT Message Format

Table 3.3 lists the input commands. These all apply to RS-232C operation except where noted as applying only to IEEE-488 operation. The examples listed under section D. also apply unless otherwise noted.

D. Remote Control Examples

The following examples show how a Model 4657 Analyzer can be operated by remote control. These examples apply to both IEEE-488 or RS-232C operation unless it is noted that an example applies to a particular interface. Except for the additional overhead of bus protocol (talking, listening, unlistening, etc.), the IEEE-488 Bus commands are simply a series of letter and number sequences to duplicate front panel operation as closely as possible. Additional commands permit data or measurement requests; and the analyzer also provides for Service Requests, Parallel Polling, Serial Polling, Device Clear, etc., as called for when using the IEEE-488 Bus.

EXAMPLE: START A STANDARD ELAPSED TEST

Operator enters:
J1, H1, J3

Analyzer responds:

```
0722 09:18:19       0
START ELAPSED TEST
B=BIT P=PARITY V=RPV
DC THRESHOLDS, HI/LO
  IN 1 +40.00/-40.00
  IN 2 +40.00/-40.00
FRAMED PRBS
ALARM 1 OFF
ALARM 2 OFF
```

The J1 command stops the timer, and H1 selects the LO/HI signal input level. These two commands would not be required if the state of the Model 4657 Analyzer is known. The J3 command performs all of the following as if separately entered; T3, C1, T3, C2, TH1, D2, M1, XM2, XT2, J2 (or ELAPSED time mode, clear display, set ELAPSED time, clear all accumulators, clear all flags, clear the timer, select ALL threshold, display PARITY errors in TOTAL ERROR SECONDS mode, print on any error, include time of day, and start test).

EXAMPLE: START A STANDARD TIMED TEST

Operator enters:

```
J1, T4, N2000000, T4, J4
```

Analyzer responds:

```
0722 09:19:06        0
START TIMED TEST
B=BIT P=PARITY V=BPV
DC THRESHOLDS, HI/LO
  IN 1 +40.00/-40.00
  IN 2 +40.00/-40.00
FRAMED PRBS
ALARM 1 OFF
ALARM 2 OFF
```

The J1 command stops the timer if it is running. It is presumed that the input signal is already at the desired setting and that the front panel is disabled or in the desired mode. The first T4 selects SINGLE TIMED mode to be set, N2000000 enters a 200 hour, 00 minute, 00 second test into the TIME display. The second T4 command sets the SINGLE-TIMED mode to the entered value, and the J4 command starts a standard TIMED test which is similar to the standard ELAPSED test. The J4 command is also equivalent to C2, TH1, XM2, XT2, D2, M1, J2 (or clear all accumulators, clear all flags, ALL threshold, log errors, display PARITY errors, TOTAL ERROR SECONDS mode, and start the timer).

EXAMPLE: REQUEST TIME

Operator enters:

```
Q2 [carriage return]
```

Analyzer responds:

```
"Human" Mode (XF2)
1005  15:49:47F          60
00:01:00  ELAPSED

"Machine" Mode (XF1)
10,05,15,49,47,1,60
0,00,01,00
```

In the "Human" mode output, the 1005 is the month and date. The 15:49:47 is the current time. The "F" is a final flag to indicate the end of a test. The 60 is the elapsed test time in seconds. The second line indicates the test elapsed time in hours, minutes, and seconds. If this output was requested during a test, the final flag would not be present, but there would be a third line indicating the time remaining in the test (only for a TIMED test).

The "Machine" mode output presents the same data but in a form more suitable to data processing. The first five numbers are the month, date, and time. The "1" is the final flag; it would be zero if the data was requested during a test. The 60 is the elapsed time in seconds. The next line indicates the elapsed time in hours, minutes, and seconds. The single digit at the start of the line indicates the type of data (0=elapsed time, 1=time remaining). During a TIMED TEST, there is a line to indicate time remaining in addition to time elapsed. If the test is an ELAPSED test, the remaining is not valid data. The last three numbers are the time remaining in the TIMED test. Note that all machine mode outputs are in a fixed format. The same quantity of numbers will be output for any given data request output, even if some of the numbers are zero. This fixed output format makes it easier to program a computer to use the data.

EXAMPLE: SET UP AND START A SPECIAL TEST

Operator enters:

J1, K3, H2, C2, T5, N100, T5, TH1, D1, M3, XM2, J2

Analyzer responds with Start of Test header

This example uses as many of the commands as is possible to set up a special test configuration. The commands are identified as follows:

J1	is Stop the Timer	T5	is set repeat-timed mode
K3	is Select parallel poll bit 3	TH1	is ALL Threshold
H2	is Select DSX-3 Input	D1	is Display BIT Error
C2	is Clear All Accumulators	M3	is Display Total Errors
T5	is select repeat-timed mode	XM2	is Log (print) All Error Data
N100	is Enter the time of 1:00 minute	J2	is Start Timer

EXAMPLE: SET THE CLOCK

Setting the TIME OF DAY and MONTH-DAY are two separate operations.

a. To set TIME OF DAY, which can only be reset when the timer is stopped, the operator enters the new time in 24-hour format. The operator enters the time ahead of the standard to which the analyzer clock is being set. Then as the standard passes through the set time, a SET command is issued. Should the operator enter "T2,N84600,S2" [carriage return] (08 hours, 46 minutes, 00 seconds), the S2 selects the Time Set function. The carriage return should be entered just as the standard passes through "8:46:00" to synchronize the clock.

b. To set the MONTH-DAY, which can only be reset when the timer is stopped, the operator enters the new data as "N1225,S1" [carriage return] for month (12) and day (25). The Model 4657 Analyzer will immediately update the internal month/day counter when carriage return is pressed. To verify the correct setting, the operator must perform a time request (see EXAMPLE: REQUEST TIME).

E. Data Request Output Formats
(Qn - Commands - See Table 3.3)

1. Human Mode Outputs (XF2)

EXAMPLE: Q1 Output:

```
0722 09:23:06F      80
          ALL    BER>E-7
ERR B     875      847
    P     867      839
    V      16        5
ES  B      22       13
    P      22       13
    V       5        1
%ES B  27.500   16.250
    P  27.500   16.250
    V   6.250    1.250
%EF B  72.500   83.750
    P  72.500   83.750
    V  93.750   98.750
BER B  2.44-7   2.37-7
    P  2.42-7   2.34-7
    V  4.47-9   1.40-9
      BER>E-6 BER>E-3
ERR B     495        0
    P     491        0
    V       0        0
ES  B       2        0
    P       2        0
    V       0        0
%ES B   2.500       0.
    P   2.500       0.
    V     0.        0.
%EF B  97.500     100.
    P  97.500     100.
    V   100.      100.
BER B  1.38-7        0
    P  1.37-7        0
    V       0        0
DCV HI     LO    OUTSEC
1+00.00 -00.01       0
2-02.81 -02.82       0
 ERRORS: 1OUT    2OUT
  BIT       0       0
  PAR       0       0
  BPV       0       0
ERROR BURSTS, MSEC
   1-10    11-99   100+
P   586       0       0
FRAMELOSS SECS        0
SIG LOSS SECS         0
POWER FAILED
```

The Q1 command produces an output like the printout on the Model 4650 printer. The length of the output is controlled by the XLn and THn command. The example is the "ALL" output. If a threshold other than ALL was selected, only data for the ALL threshold and the selected threshold would be output. If the "PART" output (XL2) was selected, only data for the selected threshold and selected error type (BIT, PARITY, or BPV) would be output, with no burst data.

EXAMPLE: Q2 Output:

```
0722 09:23:47F      80
00:01:20  ELAPSED
```

See example in paragraph entitled: EXAMPLE: REQUEST TIME for an example of the Q2 output.

EXAMPLE: Q3 Output:

```
0722 09:23:58F      80
FRAMED PRBS
ALARM 1 OFF
ALARM 2 OFF
```

This output indicates the current analyzer status in RUN mode, and history status in STOP mode.

EXAMPLE: Q4 Output:

```
0722 09:24:17F      80
         ALL    BER>E-7
ERR P     867      839
ES  P      22       13
%ES P  27.500   16.250
%EF P  72.500   83.750
BER P  2.12-7   2.34-7
       BER>E-6 BER>E-3
ERR P     491        0
ES  P       2        0
%ES P   2.500       0.
%EF P  97.500     100.
BER P  1.37-7        0
```

This output gives data for the selected error type only.

EXAMPLE: Q5 Output:

```
0722 09:24:32F      80
ERROR BURSTS, MSEC
   1-10    11-99  100+
P   586       0      0
```

This output gives burst data.

EXAMPLE: Q7 Output:

```
0722 09:24:44F      80
0722 09:21:42
POWER DOWN
0722 09:22:33
POWER UP
```

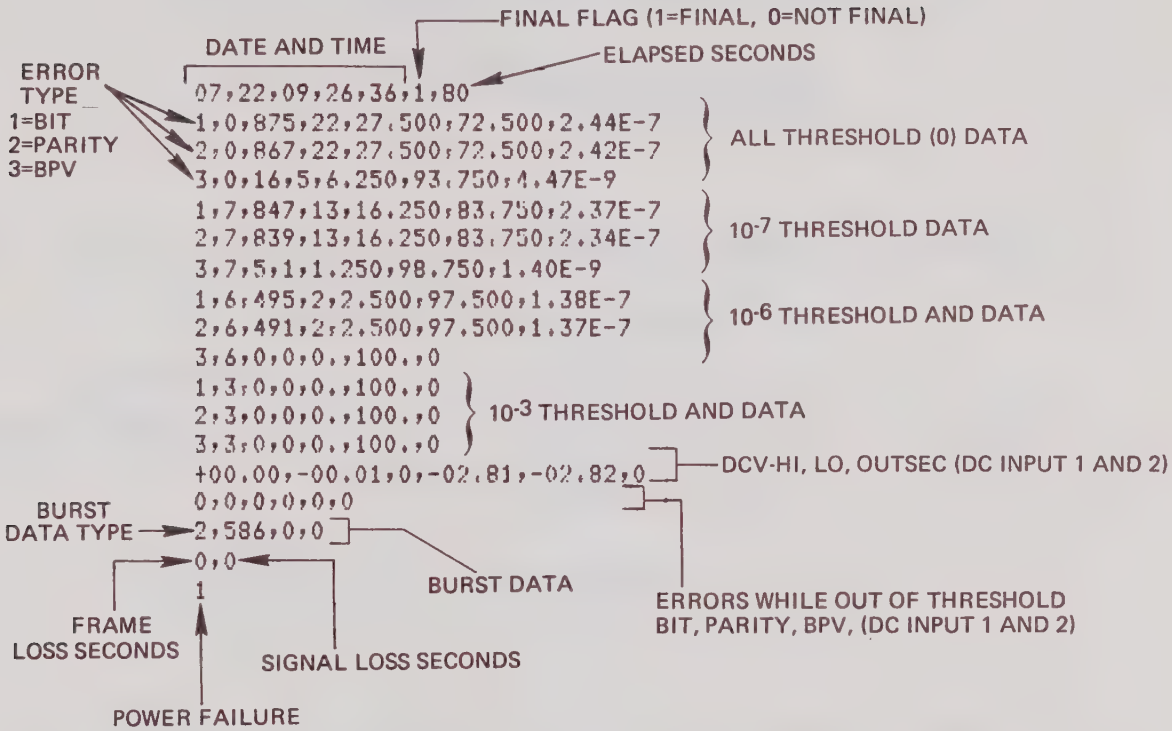
This output indicates the times of the last power-down and power-up.

2. Machine Mode Output (XF1)

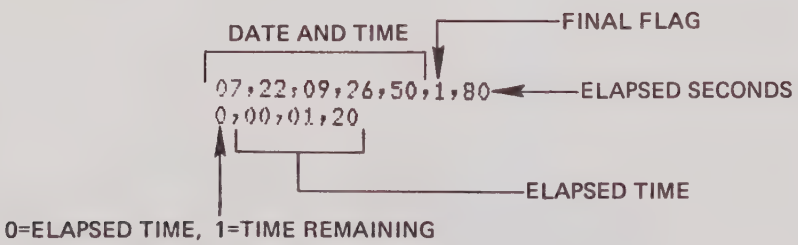
The following example contains the same data as the Human Mode outputs in the preceding section (except the current time numbers are different). Com-

pare these examples with the Human Mode Outputs.

EXAMPLE: Q1 Output:

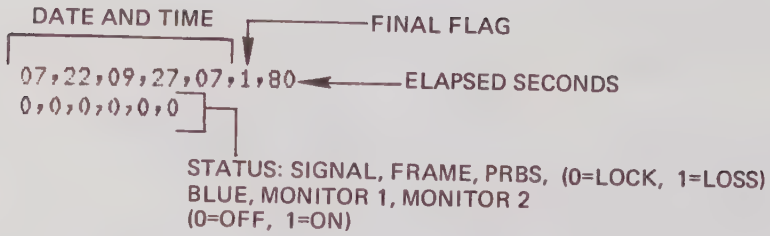


EXAMPLE: Q2 Output:

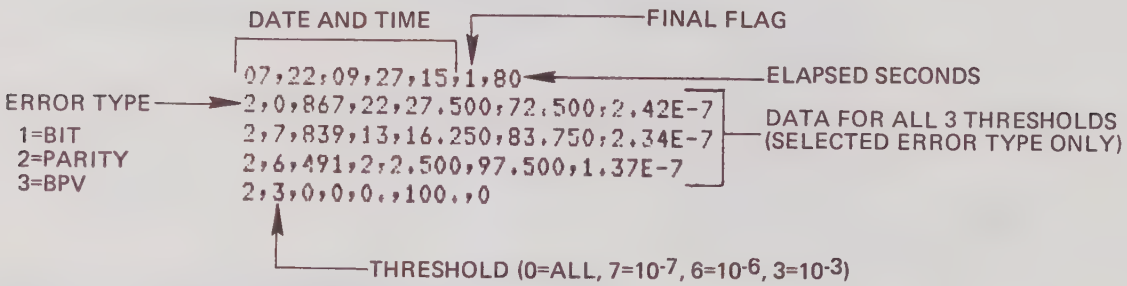


See example in paragraph entitled: EXAMPLE: REQUEST TIME for explanation.

EXAMPLE: Q3 Output:



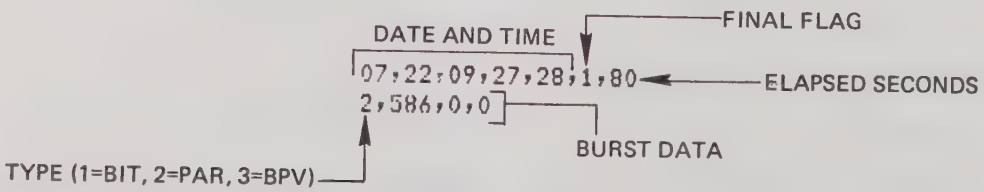
EXAMPLE: Q4 Output:



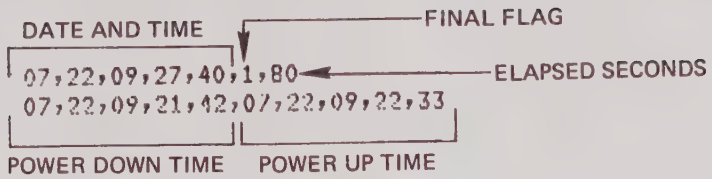
Q4 produces the same output as a Q1 except it is for the selected error type only (Bit, Parity, or BPV). The first number in the second row indicates the error type: 0=BPV, 1=Bit, 2=Parity.

EXAMPLE: Q5 Output:

The top line is the same as in Q3.

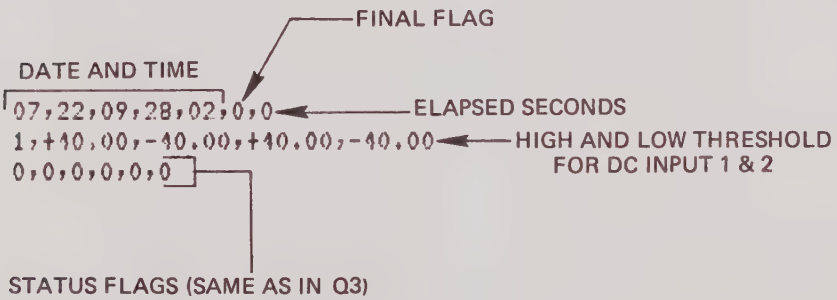


EXAMPLE: Q7 Output:



*Note: To receive the current status information, it is necessary to issue two SR commands before a serial poll command. If only one SR is issued, the data will be the status prior to the current status, and if no SRs are issued, the data will be from two status changes ago.

EXAMPLE: Machine Mode Start of Test Header:



CONVERSION OF VOLTAGE AND POWER RATIOS TO DECIBELS

The basic chart below indicates the number of decibels (dB) corresponding to the listed ratios of voltage or power over the range of −20 to +20 dB. For voltage or power ratios greater than those included in the chart, the ratio can be broken down into a product of two numbers, the value in dB for each found separately, and the two results added. Example: To convert a power ratio of 2,000:1 to dB, express 2,000\as 2×10^3; the number of dB corresponding to a power ratio of 2 is very nearly 3, and the number of dB for a power ratio of 10^3 is 30. Therefore, the power ratio of 2,000:1 is approximately 30 dB + 3 dB = 33 dB. In the lower righthand corner of the chart dB values for voltage and power ratios of integral powers of 10 are given.

Voltage Ratio	*Power Ratio*	*−dB+*	*Voltage Ratio*	*Power Ratio*	*Voltage Ratio*	*Power Ratio*	*−dB+*	*Voltage Ratio*	*Power Ratio*	*Voltage Ratio*	*Power Ratio*	*−dB+*	*Voltage Ratio*	*Power Ratio*
1.000	**1.000**	**0**	**1.000**	**1.000**	**.447**	**.200**	**7.0**	**2.239**	**5.012**	**.200**	**.0398**	**14.0**	**5.012**	**25.12**
.989	.977	.1	1.012	1.023	.442	.195	7.1	2.265	5.129	.197	.0389	14.1	5.070	25.70
.977	.955	.2	1.023	1.047	.437	.191	7.2	2.291	5.248	.195	.0380	14.2	5.129	26.30
.966	.933	.3	1.035	1.072	.432	.186	7.3	2.317	5.370	.193	.0372	14.3	5.188	26.92
.955	.912	.4	1.047	1.096	.427	.182	7.4	2.344	5.495	.191	.0363	14.4	5.248	27.54
.944	.891	.5	1.059	1.122	.422	.178	7.5	2.371	5.623	.188	.0355	14.5	5.309	28.18
.933	.871	.6	1.072	1.148	.417	.174	7.6	2.399	5.754	.186	.0347	14.6	5.370	28.84
.923	.851	.7	1.084	1.175	.412	.170	7.7	2.427	5.888	.184	.0339	14.7	5.433	29.51
.912	.832	.8	1.096	1.202	.407	.166	7.8	2.455	6.026	.182	.0331	14.8	5.495	30.20
.902	.813	.9	1.109	1.230	.403	.162	7.9	2.483	6.166	.180	.0324	14.9	5.559	30.90
.891	**.794**	**1.0**	**1.122**	**1.259**	**.398**	**.159**	**8.0**	**2.512**	**6.310**	**.178**	**.0316**	**15.0**	**5.623**	**31.62**
.881	.776	1.1	1.135	1.288	.394	.155	8.1	2.541	6.457	.176	.0309	15.1	5.689	32.36
.871	.759	1.2	1.148	1.318	.389	.151	8.2	2.570	6.607	.174	.0302	15.2	5.754	33.11
.861	.741	1.3	1.161	1.349	.385	.148	8.3	2.600	6.761	.172	.0295	15.3	5.821	33.88
.851	.724	1.4	1.175	1.380	.380	.145	8.4	2.630	6.918	.170	.0288	15.4	5.888	34.67
.841	.708	1.5	1.189	1.413	.376	.141	8.5	2.661	7.079	.168	.0282	15.5	5.957	35.48
.832	.692	1.6	1.202	1.445	.372	.138	8.6	2.692	7.244	.166	.0275	15.6	6.026	36.31
.822	.676	1.7	1.216	1.479	.367	.135	8.7	2.723	7.413	.164	.0269	15.7	6.095	37.15
.813	.661	1.8	1.230	1.514	.363	.132	8.8	2.754	7.586	.162	.0263	15.8	6.166	38.02
.804	.646	1.9	1.245	1.549	.359	.129	8.9	2.786	7.762	.160	.0257	15.9	6.237	38.90
.794	**.631**	**2.0**	**1.259**	**1.585**	**.355**	**.126**	**9.0**	**2.818**	**7.943**	**.159**	**.0251**	**16.0**	**6.310**	**39.81**
.785	.617	2.1	1.274	1.622	.351	.123	9.1	2.851	8.128	.157	.0246	16.1	6.383	40.74
.776	.603	2.2	1.288	1.660	.347	.120	9.2	2.884	8.318	.155	.0240	16.2	6.457	41.69
.767	.589	2.3	1.303	1.698	.343	.118	9.3	2.917	8.511	.153	.0234	16.3	6.531	42.66
.759	.575	2.4	1.318	1.738	.339	.115	9.4	2.951	8.710	.151	.0229	16.4	6.607	43.65
.750	.562	2.5	1.334	1.778	.335	.112	9.5	2.985	8.913	.150	.0224	16.5	6.683	44.67
.741	.550	2.6	1.349	1.820	.331	.110	9.6	3.020	9.120	.148	.0219	16.6	6.761	45.71
.733	.537	2.7	1.365	1.862	.327	.107	9.7	3.055	9.333	.146	.0214	16.7	6.839	46.77
.724	.525	2.8	1.380	1.905	.324	.105	9.8	3.090	9.550	.145	.0209	16.8	6.918	47.86
.716	.513	2.9	1.396	1.950	.320	.102	9.9	3.126	9.772	.143	.0204	16.9	6.998	48.98
.708	**.501**	**3.0**	**1.413**	**1.995**	**.316**	**.100**	**10.0**	**3.162**	**10.000**	**.141**	**.0200**	**17.0**	**7.079**	**50.12**
.700	.490	3.1	1.429	2.042	.313	.0977	10.1	3.199	10.23	.140	.0195	17.1	7.161	51.29
.692	.479	3.2	1.445	2.089	.309	.0955	10.2	3.236	10.47	.138	.0191	17.2	7.244	52.48
.684	.468	3.3	1.462	2.138	.306	.0933	10.3	3.273	10.72	.137	.0186	17.3	7.328	53.70
.676	.457	3.4	1.479	2.188	.302	.0912	10.4	3.311	10.96	.135	.0182	17.4	7.413	54.95
.668	.447	3.5	1.496	2.239	.299	.0891	10.5	3.350	11.22	.133	.0178	17.5	7.499	56.23
.661	.437	3.6	1.514	2.291	.295	.0871	10.6	3.388	11.48	.132	.0174	17.6	7.586	57.54
.653	.427	3.7	1.531	2.344	.292	.0851	10.7	3.428	11.75	.130	.0170	17.7	7.674	58.88
.646	.417	3.8	1.549	2.399	.288	.0832	10.8	3.467	12.02	.129	.0166	17.8	7.762	60.26
.638	.407	3.9	1.567	2.455	.285	.0813	10.9	3.508	12.30	.127	.0162	17.9	7.852	61.66
.631	**.398**	**4.0**	**1.585**	**2.512**	**.282**	**.0794**	**11.0**	**3.548**	**12.59**	**.126**	**.0159**	**18.0**	**7.943**	**63.10**
.624	.389	4.1	1.603	2.570	.279	.0776	11.1	3.589	12.88	.125	.0155	18.1	8.035	64.57
.617	.380	4.2	1.622	2.630	.275	.0759	11.2	3.631	13.18	.123	.0151	18.2	8.128	66.07
.610	.372	4.3	1.641	2.692	.272	.0741	11.3	3.673	13.49	.122	.0148	18.3	8.222	67.61
.603	.363	4.4	1.660	2.754	.269	.0724	11.4	3.715	13.80	.120	.0145	18.4	8.318	69.18
.596	.355	4.5	1.679	2.818	.266	.0708	11.5	3.758	14.13	.119	.0141	18.5	8.414	70.79
.589	.347	4.6	1.698	2.884	.263	.0692	11.6	3.802	14.45	.118	.0138	18.6	8.511	72.44
.582	.339	4.7	1.718	2.951	.260	.0676	11.7	3.846	14.79	.116	.0135	18.7	8.610	74.13
.575	.331	4.8	1.738	3.020	.257	.0661	11.8	3.890	15.14	.115	.0132	18.8	8.710	75.86
.569	.324	4.9	1.758	3.090	.254	.0646	11.9	3.936	15.49	.114	.0129	18.9	8.811	77.62
.562	**.316**	**5.0**	**1.778**	**3.162**	**.251**	**.0631**	**12.0**	**3.981**	**15.85**	**.112**	**.0126**	**19.0**	**8.913**	**79.43**
.556	.309	5.1	1.799	3.236	.248	.0617	12.1	4.027	16.22	.111	.0123	19.1	9.016	81.28
.550	.302	5.2	1.820	3.311	.246	.0603	12.2	4.074	16.60	.110	.0120	19.2	9.120	83.18
.543	.295	5.3	1.841	3.388	.243	.0589	12.3	4.121	16.98	.108	.0118	19.3	9.226	85.11
.537	.288	5.4	1.862	3.467	.240	.0575	12.4	4.169	17.38	.107	.0115	19.4	9.333	87.10
.531	.282	5.5	1.884	3.548	.237	.0562	12.5	4.217	17.78	.106	.0112	19.5	9.441	89.13
.525	.275	5.6	1.905	3.631	.234	.0550	12.6	4.266	18.20	.105	.0110	19.6	9.550	91.20
.519	.269	5.7	1.928	3.715	.232	.0537	12.7	4.315	18.62	.104	.0107	19.7	9.661	93.33
.513	.263	5.8	1.950	3.802	.229	.0525	12.8	4.365	19.05	.102	.0105	19.8	9.772	95.50
.507	.257	5.9	1.972	3.890	.227	.0513	12.9	4.416	19.50	.101	.0102	19.9	9.886	97.72
.501	**.251**	**6.0**	**1.995**	**3.981**	**.224**	**.0501**	**13.0**	**4.467**	**19.95**	**.100**	**.0100**	**20.0**	**10.000**	**100.00**
.496	.246	6.1	2.018	4.074	.221	.0490	13.1	4.519	20.42		10^{-3}	30		10^3
.490	.240	6.2	2.042	4.169	.219	.0479	13.2	4.571	20.89	10^{-2}	10^{-4}	40	10^2	10^4
.484	.234	6.3	2.065	4.266	.216	.0468	13.3	4.624	21.38					
.479	.229	6.4	2.089	4.365	.214	.0457	13.4	4.677	21.88		10^{-5}	50		10^5
.473	.224	6.5	2.113	4.467	.211	.0447	13.5	4.732	22.39	10^{-3}	10^{-6}	60	10^3	10^6
.468	.219	6.6	2.138	4.571	.209	.0437	13.6	4.786	22.91		10^{-7}	70		10^7
.462	.214	6.7	2.163	4.677	.207	.0427	13.7	4.842	23.44	10^{-4}	10^{-8}	80	10^4	10^8
.457	.209	6.8	2.188	4.786	.204	.0417	13.8	4.898	23.99		10^{-9}	90		10^9
.452	.204	6.9	2.213	4.898	.202	.0407	13.9	4.955	24.55					
										10^{-5}	10^{-10}	100	10^5	10^{10}
											10^{-11}	110		10^{11}
										10^{-6}	10^{-12}	120	10^6	10^{12}

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Instruction Manual Update

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